the stranger

GREENPEACE

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THE HINDUSTAN TIMES, NEW DELHI, WEDNESDAY OCTOBER 2 1996

Toxic gas was chlorine; 2 held

HT Correspondent

NEW DELHI, Oct. 1
The intensely choking gas which spread in the Anand Lok area of South Delhi causing panic in the area was the handiwork of two employees at the swimming pool of the Siri Fort Sports Complex, who dumped a leaking chlorine cylinder into the pool.

The swimming pool contrac... Mr S. K. Gandhi, was report... absconding. The police have r... vered the empty cylinder.

The Defence Colony p... were totally flummoxed by ... nauseating gas leak to begin w... They even broke open the door... the science laboratories of G... College, right across the road f... the spot on Siri Fort Road wh... the impact of the gas leak was ...

Delhi Govt told to expedite relocation of polluting units

1 Nov 96

By Our Legal Correspondent

NEW DELHI: As countdown for shifting the polluting industrial units has begun, the Supreme Court on Wednesday asked the Delhi government to expeditiously invite applications for 5,000 flatted factories to be constructed on 102 acres of land within the urban limits of the city.

Saying that as many industries illegally operating in the residential and non-residential areas in the Capital should be allotted accommodation, Justice Kuldip Singh and Justice S Saghir Ahmad ...

HC directive to enforce ban on PVC trade

Staff Reporter

New Delhi

THE DELHI High Court on Friday issued a set of wide-ranging directions to enforce the ban on PVC trade in Jwalapuri and nearby areas in West Delhi and warned police, MCD and DDA that any laxity on their part in implementing these would invite contempt proceedings.

Noting that the ban imposed in June 1996 was "merely on paper", a Division Bench consist-...

Board) and police have to share the blame in not implementing the ban with all seriousness.

The court observed that none of these parties had disputed that the ban was imposed in public interest and was necessary to protect the health and lives of lakhs of citizens.

Basing its directions on the suggestions given by these bodies, the court said, ... stand why ... could not ... ment the sug... necessary me...

Ganga aches for purity

30 June

HARDWAR, June 29 (UN...
The increasing pollution of th... Ganga water has led to degrad... tion of its properties.

The chemical contents of th... water have gone over eight unit... beyond the permissible limit ... seven units. Besides, the water ... becoming saline, its temperatu... has gone up to 16.1 degree celci... from 15.3 and the flow is slowin... down gradually, according to e... vironmentalists.

Concerned at the increasin... pollution, environmentalists an... scientists held a meeting at Har... war recently to discuss vario... steps to reduce the pollution leve...

Scientists of the Pollution Co... trol Research Institute, in the... study, warn that unless steps a... taken in time, the water of Gang... will become quite unfit for use.

The study shows that the poll... tion in the Ganga starts fro... Rishikesh and gradually increase... at Hardwar and reaches its highe... level at Gurhmukteshwar.

It points out that the temper... ture conductivity of water is d... creasing which may lead to brea...

...age of ...oxygen

...lion litres of polluted water is being released into the Ganga daily.

Mr Satya Prakash, the planning ...

Chlorine leak leads to evacuations

9 Oct 1996

BHAWANIPATNA: All the 250 families of Bandopala village, eight km from here, were evacuated to safer places following leaks from an abandoned chlorine gas tank of the Bhawanipatna water supply pumping station of the Public Health Department on Monday. According to official sources, the affected persons were complaining of chest pain, irritation and burning sensation inside after the tank lying unused for six years started leaking on Monday. Two fire brigade personnel fell unconscious while evacuating the affected people from the village, sources said.

Bhopal water still not free of toxic waste

BHOPAL: Toxic and hazardous waste which was dumped regularly for years outside the premises of the Union Carbide India Limited (UCIL) until the Bhopal gas disaster, is posing a grave health hazard for the local residents who continue to drink contaminated water.

According to the Bhopal Group for Information and Action (BGIA), several hazardous chemicals were routinely dumped outside the premises of the multi national factory since it was set up in 1969 till the gas tragedy in 1984. All effluents were dumped in an open pit near the eastern wall of the factory and some were discharged into the solar evaporation ponds situated behind, said BGIA founder Satinath Sarangi.

Each year, during the rains the ... contamina-...

Plastic menace

● Plastic is everywhere in Haiti. Widely used and quickly disposed of, the substance is an environmental nuisance. In an attempt to reduce the amount of plastic litter, the ministry of the environment is at work on a proposal to impose special import tariffs on polyethylene resin, a key ingredient used to manufacture the substance.

A bill to enforce this will be presented to parliament before the end of the year. Plastic utensils and certain other manufactured items will be exempted. Proceeds from the tariff will subsidise development of a recycling industry in Haiti according ...

Buffaloes make a protest against chlorinated water

Rema Nagarajan
New Delhi

INCREASED QUANTITY of chlorine in potable water has enraged cattle owners in Najafgarh, Outer Delhi, who feel the water is harmful for their animals, especially the buffaloes.

The animals refused to drink water pumped from a tube well. The villagers too did not like the taste of water since the Delhi Water Supply Undertaking has increased the chlorine content to check increased bacterial and other infections.

But, the local residents said, the slightly sour taste of the water due to chlorine was never objected to, till their buffaloes ...

The harried milkmen accompanied with large number of villagers rushed to the tube well and beat up the class IV MCD employee who manned the tube well last week.

The agitators warned the employee of dire consequences, if he mixed anything in the water, which did not suit the palate of their buffaloes and affected their milk sale promotion.

Later, when the Director of Health Services Dr Chaudhary along with MCD officials visited the area, the irate people gathered around to complain of the water which was made unfit for drinking by the MCD.

The health personnel and the MCD considered the problem to be genuine. But deep tube wells in that area had added chlorine ...

Rajasthan will not allow polluting units

14 Sept

The Times of India News Service

JAIPUR: The Rajasthan State Pollution Control Board will not allow any polluting industrial unit, proposed to be shifted from Delhi under a Supreme Court order, to be rehabilitated in the state.

"The board will permit only such industries which fulfil the obligation of environment and pollution control laws," R.K. Meena, chairman of the board said.

There had been panic when the state government had announced that it would start a campaign in Delhi to woo the ousted industries, as it was thought that all the units would be hazardous.

During a meeting of industries ministers of the National Capital Region, Delhi's minister had clarified that the units had been ordered out to lessen the burden and some were in the non-polluting or least polluting categories.

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The Stranger

The Chlorine Industry in India

Chlorine

Atomic Weight 35

Chlorine in an element of the halogen group, of which the other members are fluorine, bromine and iodine. These elements have only one electron missing. They are very reactive. After fluorine, chlorine is the most reactive, non metal element.

Chlorine is among the 20 most abundant elements. In one tonne of seawater, there is an average of 1.6kg chlorine. But in water as well as in mineral formations, chlorine exists in the safe, inorganic form as the safe negative chloride ion (salt).

Properties: Greenish-yellow gas, liquid, rhombic crystals.

Hazard classification: non-flammable gas, poison.

Toxicity: Poison to humans by inhalation,. A strong irritant to eyes and mucus membranes. Concentrations of 50ppm are dangerous for even short exposures, 1000ppm may be fatal, even where the exposure is brief.

Contents

SUMMARY AND CONCLUSIONS

"Everything has changed except for our way of thinking"
International Joint Commission 1994

Summary and Conclusions

Concerned about the growing evidence of risks to the environment and human health from industrial uses of chlorine, Greenpeace has campaigned internationally over a number of years for a global phase-out of organochlorines (the compounds made when chlorine bonds with carbon) as a class of chemicals.

The chlorine industry is not the only source of toxic contamination however chlorine chemicals, in particular organochlorines feature as roughly 40percent of chemical compounds listed world-wide for priority regulation.

From small beginnings, the manufacture of chlorine has grown to an industry, producing some 40 million tonnes of chlorine gas annually. But humanity and the earth's environment have paid a brutal price for the development of this cornerstone of industrial chemistry. Chlorine chemistry is at the root of many of the most serious toxic threats on the planet.

Most of Greenpeace's work has been concentrated in the heartland of the industry, in North America and Europe. However, in recent years we have watched the rapid expansion of the industry into less industrially developed regions and particular into India, Latin America, and China.

This Greenpeace International report is the first comprehensive look at the past, current and future threat of chlorine chemistry to India. Our conclusions are based on government documents, interviews with government officials, NGOs and citizens.

Already chlorinated chemicals contaminate India's environment and her people, posing a long term threat. India is set for massive expansion of chlorine chemistry. This expansion comes at a time when government authorities cannot even cope with current levels of pollution.

Indeed, the global community, under the auspices of the United Nations Environmental Programme (UNEP) has recently embarked on a process of eliminating a priority list of persistent organics compounds, or "POPs", all of which are organochlorines and mostly pesticides, many of which are still used in India (Section 4b). Dioxins and furans, the most hazardous chemicals synthesised as by-products of chlorine chemistry are included in this list. Levels of these compounds are presumed low in India, given the small uses of chlorine relative to the population but will inevitably rise as the industry expands.

Central to our investigation was a programme of sampling and analysing effluent discharges from various industrial sources. We focused on potential entry of organochlorines into the environment from industrial processes but not to the exclusion of the impact of other hazardous chemical sectors.

Among the findings of this report are:

- India is one of the few countries still manufactaring and using the most notorious chlorinated pesticides, some of which are targeted for global phase-out by the world community. We mention the newly discovered impacts of these chemicals on human reproduction and fertility.

  While the regulatory authorities have committed to eliminate many organochlorines pesticides, evidence shows that even "restricted" pesticides are readily available on the market. Government prevaricates with conflict of opinion in different ministries. (Section 4b)

- Statistics from both government and industry show that chlorine-based industries are set to substantially increase capacity in India. These include: the primary production of elemental chlorine through the chlor-alkali process and its key uses for bleaching wood pulp to make paper and viscose rayon; as an intermediate in the formulation of biocides; and as the main ingredient of the plastic, PVC.

  If industry figures are to be believed then the chlor-alkali industry will increase capacity from about 1.2 million tonnes per year (TPA) by about 50percent to 1.8 TPA million by the end of 1997. Expansion of the PVC industry is set to increase dramatically from 500,000 TPA to 1.2 million TPA by the end of 1998. Much of this PVC expansion is accounted for by Reliance Industries, who have ambitions to become a major world player in petro-chemicals.
- Officials of the Central Pollution Control Board (CPCB) and the State Pollution Control Boards admit that they are not equipped to either monitor or regulate this onslaught of chemical industrial development.

Sampling and Analysis

A scientist from the Greenpeace Research Laboratories, based at the University of Exeter, UK, visited key industrial sites in Gujarat, Maharashtra, Delhi and Tamil Nadu during April 1996, in order to obtain a preliminary evaluation of procedures employed in the handling of waste streams by the chemical industry. During this period, over 100 samples were obtained of industrial wastewaters, solid wastes and sediments. These samples were returned to the UK for analysis of organic and heavy metal contaminants.

The sampling programme focused in particular on waste streams at their point of entry to the environment (ie. post-treatment, where treatment systems were operational). The programme was designed to allow evaluation of the efficacy of existing and proposed future waste treatment facilities, and the degree of protection afforded by current pollution regulations and monitoring protocols. In many cases, waste streams were inadequately treated.

In general the results of these analyses indicated the following:

- Levels of toxic and persistent organic pollutants or heavy metals contained within wastewaters discharged to open collection channels and river systems, and within solid wastes discarded on open dump sites, were found to be extremely high, both in relative and absolute terms.
- Industrial effluents were frequently highly complex in composition, containing, in some cases, hundreds of organic compounds, a high proportion of which could not be identified.
- Of those which were identifiable, chlorinated organic compounds (organochlorines) were particularly abundant, reflecting the extensive use of chlorine chemistry in the industrial sector.

Specifically related to each sector of the chlorine industry we discovered that:

Chlor-alkali production

Discharges of mercury from Shriram Food and Fertiliser Industries in Delhi have led to receiving waters being over 65 times more contaminated than the maximum which would be permitted in Europe. Concentrations of mercury in the effluent are between one and three million time higher than might be expected in an uncontaminated water course.

Similar quantities of mercury were found in the effluent stream of Chemplast Sanmar at Mettur Dam in Tamil Nadu. We concluded that: "Both these plants are grossly violating CPCB limits for discharges of mercury but it is unlikely that any monitoring is taking place or any legal action contemplated by the relevant authority." (Section 2)

Pulp and Paper

The pulp and paper industry, despite boom time and enormous capital investments, have ignored the problems of organochlorine discharges and failed to invest in chlorine-free or chlorine reducing technologies. We found that:

Rayon grade pulping operations by SIV Industries near Coimbatore in Tamil Nadu, Seshasayee Paper and Board Mills, near Erode, Tamil Nadu, Central Pulp mills, Fort Songadh, Gujarat and Bellapur Pulp Mill, Yamunanager, Haryana are all discharging a complex range of highly dangerous organochlorines. Some of these compounds indicate the presence of the most toxic synthetic chemical known, dioxin. Yet some mills are even offering this effluent to irrigate farmlands.

A senior official at the CPCB admitted that, despite a regulatory limit being set, not one of the State Pollution Control Boards had installed facilities to test for organochlorines: "Quite simply nothing has been done until now to control or regulate discharges of organochlorines from pulp mills. As we have seen, efforts to use wastewater for agricultural purposes are fraught with danger. Even though the CPCB recognises that the only answer is to move out of chlorine bleaching, little has happened. There are few indications that the situation will improve. The CPCB seems totally impotent in this regard." (Section 3.6).

PVC

Primary PVC production is a well known source of hazardous organochlorines, including dioxin. Our samples from Chemplast Sanmar's facility, at Mettur Dam, Tamil Nadu, showed the presence of hexachlorobutadiene (HCBD) which is a known toxin and indicates the presence of dioxin.

The PVC industry is set to vastly expand production in India. This will mean PVC plastic replacing traditional materials and creating new markets, in order to repay costly investment. The industry plans to deal with the expected waste crisis by promoting recycling. We expose PVC recycling as "down-cycling", only temporarily able to deal with the flood of products ultimately waiting for disposal. The reality is more toxic materials in landfills and the construction of incinerators. PVC, when burnt in either backstreet down-cycling operations, smelters to recover metals or incinerators will create dioxin.

Small Units in Gujarat.

We focused on some the large industrial estates in Gujarat - Nandesari, Vapi and Ankleshwar (Section 4) where working conditions could be described as 'medieval', and some of the most

hazardous organochlorines (with other toxins) are randomly discharged to open channels. We saw workers in Ankleshwar covered head to toe in dyes containing carcinogenic, chlorobenzenes. In Vapi, workers washed themselves and their tools in some of the most hazardous chemicals known.

Environmental protest in Gujarat has forced some changes and there are plans to construct "secure landfills", incinerators and a long outfall to the sea. We concluded that these, along with treatment facilities, will serve only to divert the problem elsewhere. Huge investment has led to large-scale chlorine-based industries being built on greenfield sites at Dahej, Jaghadia and elsewhere in Gujarat. Some plants are already operating without full environmental clearance. This development will lead to further contamination of soil, groundwater and rivers; in particular the Narmada estuary.

Common Effluent Treatment Plants (CETPs).

We analysed samples after treatment by a CETP near Nandesari Industrial Estate in Gujarat and found a range of highly hazardous organochlorines still present in the waste-streams being discharged to the Narmada Estuary. These chemicals were similar to those found in some pulp mill effluent and indicated that dioxins were present. Companies responsible included Indian Petrochemical Corporation Ltd (IPCL) and Gujarat Alkalies and Chemicals (GACL).

We reviewed the technology of these CETPS and concluded that they will not adequately eliminate or destroy a range of dangerous chemicals, especially persistent organic pollutants such as the organochlorines.

Most commentators, The World Bank, the CPCB and officials in the State Pollution Control Authorities, recognise that pollution control authorities are ill-equipped to deal with existing, let alone expanding, polluting industries. Limiting industrial pollution, in the absence of either political will by the Ministry of Environment (MOEF) or resources by the pollution control authorities, has been left to the judiciary through Public Interest Litigation (PIL).

Public attention has been focused on the visible pollution streams of the 3 million small units throughout India which contribute about 45percent of industrial production. Finance, in particular through the World Bank is being found to build Common Effluent Treatment Plants (CETP) for these units.

Greenpeace Scientists concluded that , "existing waste treatment facilities are categorically not adequate to eliminate such contaminants":

- The characterisation of waste streams is generally very poor. Although some heavy metals are included on lists of contaminants to be monitored by the Industrial Development Corporations, it appears that such analyses are carried out infrequently. In the case of organic pollutants, the analytical capabilities required for effluent characterisation and monitoring simply do not exist within the pollution control system.

  As a result of the very limited range of parameters for which routine monitoring is possible and for which legislative limits exist, effluents may be considered acceptable for discharge to receiving waters although they contain high concentrations of persistent organic pollutants.
- The plants are designed to address only a limited range of physical, biological and chemical variables. These variables include pH, conductivity, dissolved and suspended solids, BOD, COD, nitrogen and phosphorus, along with certain other major ions. Such treatment facilities are fundamentally unable to deal adequately with heavy metals and persistent organic compounds; indeed, their operation may well be severely hindered by the presence of such

contaminants, which can exert toxic effects on the micro-organisms responsible for biological waste treatment.

- At best, common effluent treatment plants may serve to concentrate persistent pollutants from liquid waste streams in to highly contaminated sludge's. Far from solving a problem, this simply creates another hazardous waste stream.

In short, this preliminary study has demonstrated that existing pollution control measures are inadequate to prevent widespread contamination of the environment with persistent pollutants and, as a consequence, to protect human health. The common effluent treatment plants proposed or under construction for industrial estates such as Ankleshwar and Vapi will not provide a solution, as such plants are unable to degrade the persistent toxic substances which represented a major component of the waste streams sampled in this investigation.

Future options

We have listed many of the substitutes and alternatives for chlorine products. Many of this are being developed in the north, where, having lived with the problem for many more years, they have evolved some effective regulatory instruments to pressure industry to adopt cleaner technologies. Industry and retailer have also responded by voluntarily looking for substitutes for chlorine-based products.

Undoubtedly some benefit would arise from increased funding for the pollution control authorities, in particular for sophisticated analytical equipment to detect and therefore regulate sources of complex organic chemicals; in particular dioxin testing technology. Command and Control is always a better policy option than Command and Ignore.

However, as we have discussed in Section 6. however well funded both in equipment and personnel, pollution control and end-of-pipe solutions alone cannot hope to stem the flow of hazardous chemicals into the environment. This is acknowledged by the Government of India in a policy statement in 1992. It stresses the preventative approach but so far remains the beginning-of-a-pipe dream.

Towards cleaner technologies

The only long-term solution is to address such contaminants at source through fundamental changes to the industrial processes employed in the chemical and manufacturing sectors.

Throughout this draft report we show, at both international and national level how communities elsewhere are forcing industry to look at products and processes rather than pollution at the end-of-pipe. Bans and phase-outs are the most effective regulatory tools but require a degree of strong political will and consensus. Economic instruments such as effluent and product charges are easier and less costly to enforce and focus attention on the key elements of production systems.

In the case of the expansion of the PVC industry, increasingly the sink for chlorine production world-wide, looking at emissions and discharges is important but increasingly we must look at the 'product as the poison' as chlorinated plastic, containing a wide variety of cancer-causing and hormone disrupting chemicals as additives spreads into every facet of everyday Indian life.

Development and the environment

Greenpeace along with other environmental groups is not opposed to development. We recognise the need to build an adequate infrastructure and technology base in India. In a recent article in "Down to Earth," magazine the Prime Minister, Mr H.D.Deve Gowda decried Indian NGO environmentalists for being 'anti-development'. He went on to say, 'Environmentalists, claim that industrial effluents released in water affect the fish. But this is not true.... There should not be a prejudiced conclusion... We have advanced technology which can be used to solve our pollution problems." Toxic industrial effluents released in water does effect fish. The 'advanced technology' Mr Gowda is so proud of, is mostly pollution control technology, such as CETPs. There is no evidence of cleaner technologies such as chlorine-free pulp operations being installed. Pollution control alone is not effective.

We disagree with his seeing "no relationship between liberalisation and the environment". India is in the process of massive industrial growth. Investment in more toxic industries will impose further burdens on India's water, land and air. Our message is *ensure that there is a link between liberalisation and the environment*; invest in a clean production strategy; use a variety of tools including seeking investment in cleaner technologies; utilise economic instruments through "command and control" legislation.

For example, to drive the expanding commodity polymer industry into manufacturing and marketing less harmful "transition materials", we suggest that government embraces the principles of "Extended Producer Responsibility" (EPR). Through mechanisms such as "take-back" legislation, industry will be forced to accept responsibility for its products instead of imposing them upon the community and authorities to regulate.

This will lead to manufacturers designing sound ecological principles into products: limiting material and energy use, creating true recyclability, as well as avoiding use of toxic substances such as those being generated by chlorine chemistry.

Introduction

It is the year 1774: In his small experimental laboratory, Swedish chemist Carl Wilhelm Scheele watched with total fascination what happened when he let a few drops of hydrochloric acid fall on a piece of manganese dioxide. Within seconds, the mineral dissolved into a dark-brown solution. But that is not all: a greenish yellow gas rose from the crucible [1, Bayer, 1995]. Chlorine had been liberated from its naturally ocurring inorganic form. Since it rarely exists in nature, a stranger had entered our biosphere.

In its elemental form chlorine is highly poisonous. In April 1915 Germany dropped 180 tonnes of chlorine gas on opposing trenches in Northern France. 15,000 French and British troops lay on the battlefield with scorched lungs. About 5,000 died.

Less than 50 years later the world woke up to the dangers of industrial uses of chlorine with the publication in 1962 of Rachel Carson's "Silent Spring" which documented the devastating effects of chlorine based pesticides on wildlife in the USA.

Modern chlorine chemistry is based on the chlor alkali process which uses electrolysis to split the sodium chloride (common salt) molecule into its constituent parts of chlorine gas and caustic soda. In the late nineteenth century both chemicals had uses for bleaching textiles and the manufacture of paper but chlorine, because of its extreme reactivity with other elements, especially carbon, became an increasingly important building block to chemical compounds such as biocides, solvents, the chlorinated plastic, PVC, and extensive use as an intermediate reactant in a whole range of industrial processes.

The Devils Element

"God created 91 elements, man a little more than a dozen and the devil one - chlorine" [1, Bayer, 1995]. Industrial chemists have behaved like Goethe's "sorcerer's apprentice"; performing magic but without the means to keep the genie they have summoned under control [1, Bayer, 1995]..

Chlorine reacts with carbon, such as oil derived methane and ethylene, to create a new range of compounds called organochlorines. These are extremely stable chemicals that can be highly toxic. They persist in the environment and our bodies and bio-accumulate as they move up the food chain from micro-organisms to the higher mammals.

US chemical giant Monsanto did not realise the effect that the industrial lubricant polychlorinated biphenyl's (PCBs) would have on wildlife and humans when they were invented in 1929. These compounds are now threatening the fertility of higher mammals such as whales and polar bears and are the cause of intelligence disorders in children whose mother's ate contaminated fish.

At the beginning of the 1940s, the chlorine compound dichlorodiphenyltrichloroethane (DDT) was praised all over the world as a wonder agent that killed insects threatening harvests and mosquitoes causing malaria epidemics in tropical regions. 15 years later it was found that DDT and associated chlorinated pesticides, such as aldrin, dieldrin, endrin, lindane, chlordane and heptachlor, remained intact for long periods of time, building up in soil and had the disastrous tendency - both for animal and humans - to accumulate in fatty tissue. As a result, DDT is passed on via the natural food chain in constantly higher concentrations.

At the time of their launch in the 1950s, the chlorofluorocarbons (CFCs) were thought to have outstandingly useful properties and be toxicologically harmless. No-one predicted how they would react with the upper ozone layer and expose large areas of the globe to harmful ultra-violet

radiation. The UN Environmental Programme (UNEP) has estimated that current ozone depletion trends will result in 300,000 cases of skin cancer worldwide each year and an unknown number of infectious diseases caused by immune system disorders.

These synthetic chemicals are now found in all living creatures. For example, through a process known as "cold condensation", organochlorines sprayed on crops in tropical climates are carried by high altitude winds to condense out into the pristine environment of the Arctic where they accumulate in plankton, seabirds, seals and polar bears and therefore the diet of Inuit people. It has been estimated that 99.9percent of pesticide gamma HCH (lindane) applied to rice paddies in Southern India evaporates to become available for long range atmospheric transport.

Organo chlorines are ubiquitous in the Indian environment: pesticides mostly gamma HCH, DDT, and BHC have been found in soils, in zooplankton, and bottom feeding fish in the coastal Bay of Bengal; [2, Shailaja and Singbal, 1994]. PCBs , DDTs, HCHs, HCBs, aldrin, dieldrin, heptachlor, heptachlor epoxide and chlordanes have been found in river dolphins from the Ganges; [3, Kannan, Tanabe, 1992]. HCH residues have been found in rain water from Hardwar; [4, Dua, Pant, 1994]. and organochlorines have even been found in the air of the capital city, Delhi [5, Kafshik, Pillal, 1986].

Most northern industrialised countries banned many of these chlorinated compounds in the early 1970s but their effects are still being identified. However, as we shall see, India still prevaricates about stopping production.

Worldwide there are about 15,000 organochlorine compounds in current use. Very few have been thoroughly tested for their toxicity or impact on the environment and human health.

Section 1 Some human health effects of organochlorines

"Our fate is connected with the animals"
Rachel Carson

1.1 Animal and human health effects

"Our fate is connected with the animals", Rachel Carson wrote over three decades ago in Silent Spring and most of our evidence of the harm these chemicals will cause to health is derived from effects on wildlife: herring gulls forming same sex-pairs and abandoning their eggs; deformed beaks in bald eagles; alligators with undersized penises; immune systems damaged in seals in the Atlantic, Mediterranean and Baltic seas.

The effects of organochlorines on the environment and in animals is well documented. The evidence of impacts on human health is growing.

As a class of chemicals, organochlorines, because of the strong molecular bond made when chlorine combines with carbon, are difficult to breakdown either in the environment or living tissue.

- Many organochlorines are very stable and they persist for long periods of time. Breakdown products, often other organochlorines, can be more toxic and persistent than the original product.
- Many organochlorines are more soluble in fats than in water and once in the environment they tend to migrate into living tissue. Contaminant levels are multiplied as they move from one level of the food chain to the next, the process known as bioaccumulation or biomagnification.

Species near the top of the food web bear the greatest burdens. Marine mammals and fish-eating birds and wildlife across the planet have the highest concentration of organochlorines in their tissues. Though many organochlorines resist biochemical alteration and excretion, they can be eliminated from the body through mother's milk, blood and semen.

Bioaccumulated organochlorines are thus transferred from one generation to the next. Infants in utero receive significant doses via cross-placental transfer. Following birth, they receive even greater doses when nursing. These doses can be many times greater than the original environmental exposures to which their mothers were subjected.

1.2 Exposure to organochlorines during pregnancy

Foetal death and spontaneous abortion:

In the dry cleaning industry, studies show women exposed to high concentration of the chlorinated solvent, perchlorethlyene, may be three and a half times more likely to suffer spontaneous abortion [6, Kyyronen and al, 1989].

One study in India concluded that there was a possible association between women experiencing stillbirths and high levels of the pesticides aldrin and DDT in their maternal blood and umbilical cords [7, Saxena and Siddiqui, 1983].

Low birth weight and reduced birth size.

Women who had eaten moderate amounts of contaminated fish from Lake Michigan in the USA, had lower birth rates and their babies had smaller heads and were born more prematurely than the babies of unexposed mothers [8, Swain, 1991].

Altered behaviour and lower intelligence.

Eleven years later, these same children born to women eating contaminated fish from Lake Michigan, were shown to grow up with low IQs, poor reading comprehension, difficulty paying attention and memory problems [9, Jacobson, 1996]

1.3 Organochlorines and cancer

Studies in exposed communities and industry workers have shown links between several organochlorines and different types of cancer:

Table 1.1 Organochlorines and Cancer

The various types of cancer that are associated with exposure to specific organochlorines.

Type of Cancer	Organochlorine
Liver	PCBs
Digestive Tract	PCBs
Pancreatic	DDT
Lung	dioxin, chloromethyl, ethers
Soft tissue sarcoma	dioxin, chlorophenols
Lymph glands	phenoxy herbicides, especially 2,4-D
Aplastic anaemia (pre-cancerous)	lindane, pentachlorophenol
Breast	DDE
Multiple cancers of all types	dioxin

Source Greenpeace International. Body of Evidence 1996.

1.4 Organochlorines and hormone disruption

Most research has concentrated on the risks of cancer in exposed populations but recently scientists discovered that a number of synthetic chemicals, including many organochlorines can, in the tiniest amounts, interfere with natural hormonal systems, leading to decreased fertility and changes in sexuality in both males and females. The most exposed populations are offspring "in utero" who are subjected to chemicals passed through the placenta and then later from breast milk. Scientific evidence shows that animals and humans respond in generally the same way to hormone-disrupting chemicals.

Concerned about the growing evidence of the effect of synthetic chemicals, USA scientist/researcher Theo Colborn gathered a group of scientists from a number of disciplines to a retreat at Wingspread, Racine, Wisconsin, USA in 1991 to assess what was known about the effects of synthetic chemicals, including organochlorines, on hormonal systems.

They concluded that, "A large number of man-made chemicals that have been released into the environment, as well as a few natural ones, have the potential to disrupt the endocrine (hormonal) system of animals, including humans. Among these are the persistent, bioaccumulative, organohalogen compounds that include some pesticides and industrial chemicals, other synthetic products, and some metals" [10, Colborn, Dumanoski, 1996]. Since 1991 the list has grown, for example, more phthalates used as additives in the chlorinated plastic PVC have become implicated.

Box 1.1 Hormone Disrupting chemicals

DDT and its degradation products

DEHP (di(2-ethylhexyl) phthalate

dicofol

HCB (hexachlorobenezne)

kelthane

kepone

lindane and other hexachlorocyclohexane congeners

methoxychlor

octachlorostyrene

synthetic pyrethroids

triazine herbicides

EBDC fungicides

certain PCP congeners

2,3,7,8 TCDD and other dioxins

2,3,7,8 TCDF and other furans

cadmium

lead

mercury

tributyltin and other organo-tin compounds

alkyl phenols (non-biodegradable detergents and anti-oxidants present in modified polystyrene and PVC's)

styrene dimers and trimers

soy products

laboratory animal and pet food products

Source: [10, Colborn, Dumanoski, 1996].

Organochlorine biocides figure as some of the most potent hormonal disrupters. DDT is regarded as a classic mimic of the female hormone, oestrogen, that elevates hormone levels. On the other hand, DDE, the breakdown product of DDT, is thought to deplete hormones in the body by accelerating their breakdown and elimination, leaving the body short of both the female hormone oestrogen and the male hormone testosterone and the other steroid hormones, which can lead to abnormally low hormone levels. Since a developing foetus is extremely sensitive to hormone levels, too little can be as devastating as too much [10, Colborn, Dumanoski, 1996].

These findings must be extremely worrisome to health authorities in India where DDT has been used extensively over the past 50 years.

A case study in the Punjab in 1993 found that 80percent of food samples were contaminated by DDT, all 244 samples of milk and its products contained residues of DDT. Likewise all 130 samples of mother's milk contained residues. Average daily intake for infants was calculated as about 13 and 24 times the World Health Organisation's recommended limits [11, Singh, 1993].

Other studies have found fertility and health problems in people exposed to these biocides in India.

Over the last fifty years sperm counts in men has fallen dramatically. The quality of sperm is also getting worse, with sperm mobility declining and the proportion of abnormal sperm rising. The incidence of testicular cancer has also increased.

A group of Indian men exposed to organochlorine pesticides, such as DDT, BHC and endosulphan, while working in cotton fields were found to have decreased fertility. There was also a significant increase in still births, neonatal deaths and congenital defects in children born to these men [12, Rupa, 1991].

In the Vietnam war, testicular size was reduced in men who sprayed dioxin-contaminated Agent Orange [13, Wolf, 1992].

In a study of 20 Indian women with unexplained infertility, 8 had elevated blood levels of the pesticide lindane and/or the wood preservative, pentachlorophenol [14, Gerhard, 1991].

However, the most potent hormonal disruptor is dioxin, a by-product of chlorine chemistry. Already known as the most potent carcinogen ever tested on a number of animal species, laboratory experiments have now shown that a small single dose of dioxin given to pregnant rats damaged the reproductive system of male offspring.

Unlike many laboratory experiments where animals receive doses much higher than those found in the environment, these findings have direct and immediate relevance to the real world. "The lowest doses given to the mother rats had been very near to the levels of dioxin and related compounds reported in people in industrialized countries such as the USA, Japan and in Europe." [10, Colborn, Dumanoski, 1996].

Ominous words as India engages in a huge expansion of its chlorine industries. There is no routine testing for dioxin in India. This is akin to building a nuclear weapon or power plant without any means of measuring radiation.

SECTION 2 THE CHLOR ALKALI INDUSTRY IN INDIA

"..The dynamic growth of chlorine chemistry during the 50s and 60s represents a decisive mistake in twentieth century industrial development, which would not have occurred had our present knowledge as to environmental damage and health risks due to chlorine chemistry then been available".

German Council of Experts, 1990. .

From the time the first five tonnes a day plant was opened at Mettur in Tamil Nadu in 1936, the Chlor-Alkali industry has grown in India to produce almost 1.2 million tonnes of chlorine in 1995/6 and a similar quantity of caustic soda. As in most industrialised countries the original driving force was the need of caustic soda for the textile industry. Chlorine was a by- product.

Table 2.1 Chlorine Production in India

Year	Chlorine Production in 1,000 of tonnes
1992-3	975
1993-4	1002
1994-5	1085
1995-6	1177

Source: Alkali Manufacturers Association of India, Annual report 1995-6 p13

During 1996, the industry is set on a path of dynamic growth to increase capacity by almost 50percent. Further plants will start construction in 1997.

Table 2.2 Additional Chlor Alkali Capacities to be commissioned in 1996-7

Name of Unit	Proposed location	State	Capacity TPA	Likely date of Commissioning
Chemfab Alkalis	Pondicherry	Pondicherry	10,000	December 1996
Gujarat Alkalis	Taluka, Bharuch	Gujarat	115,500	December 1996
Modi Alkalis	Alwar	Rajasthan	13,200	November 1996
Hindustan Organic	Rasyani	..	20,000	June 1996
Indian Rayon	Veraval,	Gujarat	33,000	June 1996
SPIC	Manali	TN	16,500	October 1996
DCM Shriram	Jhagadia, Bharuch	Gujarat	50,000	March 1996
Search Chem Inds	Jhagadia, Bharuch	Gujarat	33,000	May 1996
Kadakia Alkalis	Ankleshwar	Gujarat	16,500	June 1996
Mardia Chemicals	Mardia Nagar,	Gujarat	99,000	June 1996
IPCL	Jageshwar,	Gujarat	130,000	September 1996
Kasyap Agro-Vit pvt	Kheda-Bidnawar	..	6,600	December 1996
Travancore-Cochin	Eloor,	Kerala	33,000	December 1996
Shree Rayalaseema	Kurnool	Karnataka	16,500	December 1996
Shriram Inds. Enterprise	Rajpura, Patiala	Punjab	82,500	July 1997
Kothari Sugar & Chem	Kattur Lalgudi,	TN	33,000	March 1997
Kanoria Chem. & Inds.	Renukoot	UP	19,800	March 1997
The West Coast Paper	Bhangur Ngr.	Karnataka	8,250	March 1997
Total			736,300	

These figures are from the Alkali Manufacturers Association and refer to caustic soda expansion. We can infer that co- production of chlorine is roughly 90percent caustic capacity. The figures and do not necessarily include non-member companies and chlor-alkali plant installed for captive use; in pulp mills for example.

Source: Alkali Manufacturers Association of India, Annual Report 1995-6, pp23-4

Yet chlor-alkali producers in India are not happy, they complain bitterly about the differential in energy costs with foreign competitors. Energy is about 70percent of the cost of making chlorine and caustic soda. Compared to international power tariff levels of between 3-4 US cents per kilowatt, current tariffs in India are close to 9 cents per kilowatt [15, Hindu, 1996]. But with India facing an estimated peak demand shortage of 28percent of energy in 1996/7 and by 2,000 a shortfall of a 80,000 MW, (about 50percent of current capacity), perhaps the question to ask is whether India can afford this industrial sector.

The industry is also protesting the recent reduction of customs duty on imports of sodium hydroxide (caustic soda) from 65percent-40percent [15, Hindu, 1996]. This, claim industry, leaders. opens the floodgates to foreign imports. Indeed, the expanding PVC sector of the chlorine industry is already shipping in chlorine derived raw materials from the Arabian Gulf and Gulf of Mexico, where energy prices are lower.

Analysts project that the planned new capacities, expected to materialise in the next three years, will lead to supply far in excess of demand, with an expected mere 70percent utilisation [15, Hindu, 1996]. The industry and downstream users will have to create new markets to give a good return on these investments.

2.1 Mercury cell pollution

There are two processes currently used by the chlor alkali industry, the older is mercury cell and the more modern is membrane cell. A small number of plants also use the obsolete diaphragm method. The greatest immediate environmental impact of the chlor-alkali comes from the use of mercury cells in the basic electrolysis process of splitting sodium chloride (common salt) into chlorine gas and caustic soda. Although mercury does not take part in the reaction, it is always lost to the environment during this process, often as a contaminant in spent brine sludges. The Central Pollution Control Board (CPCB) has recognised this problem. "Mercury emissions through liquid, gaseous and solid waste routes are the major pollution problems of mercury cell chlor-alkali industry" [16, CPCB, 1982]. Consequently strict limits of 0.01 ppm (mg/l) of total concentration in the final effluent are placed on the industry.

From 1986 onwards, the Government of India has made it mandatory that new chlor-alkali plant should only be installed with membrane cell technology. But conversion has been slow with the industry estimating that roughly 60percent of production is still through mercury cell. Other analysts put the figure as high as nearly 82percent [17, TERI, 1995]. In Europe the industry has been ordered to replace all mercury cells by the year 2010.

Mercury is highly poisonous, with severe effects on the human nervous system. Often symptoms occur long after exposure has ceased. The most infamous episode of mercury poisoning happened in Japan when as many as 20,000 people, from fishing communities eating mercury contaminated fish from coastal waters downstream of a chlor-alkali facility, became affected over a number of years in the 1970's. Many died and others suffered severe neurological dysfunction. This became known as the Minimata disease after the region concerned. As a consequence, Japan quickly converted its chlor-alkali industry to the less polluting and less energy intensive membrane cell process.

In India, "the problem of mercury pollution remained untackled" [15, Hindu, 1996]. At least 23 mercury cell plants remain functioning throughout the Union, discharging wastes into rivers and coastal waters. V Ramadurai, past president of Standard Alkalies, operating in the Thane district, near Mumbai, outlined the problem, "Brine sludge is dumped on our own factory premises. We have cut down drastically on the mercury content but it is still 2-3 ppm. Whatever we dump we dig into pits and do our own sampling. During monsoon what is dumped is carried away."

(Interview, 12 March 1996). He also thought that most industrial wastes in the area were dumped illegally in "clandestine operations".

Table 2.3 Mercury Cell Units in India

Name of Unit	Actual production 1995-96
Andhra Sugars	46,235
Atul Products	11,477
Ballarpur Inds, Harwar	55,726
Bihar Caustic	38,853
Century Rayon	19,886
Chemplast Sanmar Ltd	44,963
DCW Ltd	53,842
Durgapur Chemicals	6,518
Grasim Industries	42,358
Gujarat Alkalies & Chem.	-
Hindustan Heavy Chemicals	12,352
Hindustan Paper Corpn	18,220
Hukumchand Jute & Indus	27,575
Jayshree Chemicals	20,247
Kanoria Chemicals	50,597
Modi Alkalies	51,550
NRC Ltd	49,676
Punjab Alkalies & Chem	49,676
Shriam Fert & Chem	33,185
Southern Petrochemicals	65,316
Standard Industries	31,906
Travancore Cochin Chem	51,603

Source: Alkali Manufacturers Association of India, Annual report, 1996.

"Monitoring of mercury discharges from each unit should be part of the watch on the environment. Mercury pollution study should be carried out in all 12 States where mercury units are located." [16, CPCB, 1982]. At least one science study in the international scientific literature has documented high levels of mercury, in the sediments of the Rushikulya estuary at Ganjam, Orissa . [Padna, 1990] Fish in this estuary are contaminated. The source is the chlor-alkali plant of Jayshree Chemicals, producing some 18,000 tonnes of chlorine annually.

Greenpeace analysis: Shiram Food and Fertilizer, Chemplast Sanmar

High concentrations of mercury were detected in the wastewater discharges from two chlor-alkali plants during Greenpeace's investigations in May 1996; Shriram Food and Fertilizer Industries in North-West Delhi, and the Chemplast Sanmar PVC facility at Mettur Dam, Tamil Nadu.

Shriram Food and Fertiliser Industries, New Delhi

At 3.26 mg/l, the discharge from the Shriram plant, to an open 'nallah' (drain) which eventually rejoins the river, is over 65 times more contaminated than the maximum which would be permitted within Europe. Concentrations in the effluent are between one and three million times higher than might be expected in an uncontaminated water course and, therefore, have a very high potential for the pollution of receiving waters.

Chemplast Sanmar PVC, Mettur Dam, Tamil Nadu

High levels of mercury were also detected in discharges from the Chemplast complex. Two effluent streams, discharging to an open channel which directs effluent ultimately to the Kaveri River, were found to contain 1.09 mg/l and 149 ug/l Hg (mercury) respectively. Neither waste stream could be traced back to a particular process, although it seems likely that the more concentrated discharge was spent brine arising from a mercury cell chlor-alkali plant. This higher value is more than 20 times greater than the EC permitted maximum. Mercury accumulation was clearly detectable in the soft sediments below the discharges, with values up to 150 mg Hg/kg sediment recorded, over 500 times what may be expected in uncontaminated river sediments.

Both these plants are grossly violating CPCB limits for discharges of mercury (0.01mg/l) but it is unlikely that any monitoring is taking place or any legal action contemplated by the relevant authority.

The CPCB have recommended that, "the study of mercury accumulation in the population at large living on river banks where mercury is discharged, particularly the fish eating population, should be carried out, with international assistance" [16, CPCB, 1982]. Present-day CPCB officials do not know if any such study has be done.

2.2 Accidents

Chlorine, in its elemental (or gas) form, is both highly poisonous and inflammable. Therefore, production procedures and transportation has to conform to the highest possible standards. A number of accidents in Indian plants, when it is being transported and used have had serious impact both within plant and on the immediate surroundings.

- In 1985 a gas leak from the chlorine plant of Shriram Foods and Fertilizer Industries in North-West Delhi killed one person and "sent panic in the capital and rendered several ill" [18, Anthony, 1995]. Two days later another, albeit minor leakage occurred. This all happened only a short while after the factory had been inspected for potential dangers. Over 200,000 people live within a three kilometre radius of this plant. This is the same plant discharging high amounts of mercury.

  The unit was shut down by the authorities but reopened some time later with stringent conditions on the right of workers to have adequate training; trade unions were empowered to report on any default or negligence of the management; the Chairman and Managing

Director of the company were made to give personal responsibility to pay compensation for any death or injury in case of escape of chlorine gas.

In this case the petitioners relied upon Article 21 of the Indian Constitution, The Right to Life and Personal Liberty. The Supreme Court accepted the position that the right to live in an environment free from pollution is a part of the fundamental Right to Life [19, HMS, 1993].

This case also led to the Supreme Court initiating a policy of ordering closure of polluting industries in crowded metropolitan areas; to be relocated in areas "where population is scarce, and establish green belts around them" [18, Anthony, 1995]. A policy of dubious wisdom, since, instead of being prevented, the pollution is just moved elsewhere.

- In the same year, in August 1985, more than 150 people were injured by a chlorine gas leak at Calico Mills Chemical Plant in Mumbai. It was the second major chlorine leak in Mumbai in two months, the fourth toxic chemical leak in five months. In June 1987 in Meerut chlorine gas was set free from an army tanker. 86 were injured; one woman later died. In August 1987 a leaking chlorine tanker parked close to a school injured several people. In February 1990. chlorine gas seeping from a small paint factory in Calcutta killed four people and injured about 90 others living in a shanty town nearby.
- Most recently, in October 1996, panic was created in Central Delhi when two employees dumped a leaking cylinder of chlorine gas into the swimming pool of a sports complex. Choking, nauseous gas spread throughout the neighbourhood.

These incidents are just a few, culled from a limited range of newspapers and databases by Greenpeace researchers [20, Greenpeace, 1991]. No doubt there are many others, and the source, chlorine gas, not reported.

The hazard of road transporting this lethal product poses special problems in India, with its overcrowded, often poorly maintained highway system. Chlorine is contained in special one tonne yellow cylinders, to limit exposure in case of accident. A spokesperson for The Indian Chemical Manufacturer's Association considers the poor state of India's roads to be their biggest environmental problem and emphasised the need for "pipeline corridors" to carry chemicals throughout the Union (Interview 13.3.96, with R R Gokhale). A policy that we hope is never implemented given the size of rural populations in India.

2.3 Uses of Chlorine in India

Table 2.4 Uses of Chlorine in India

Use	1990	1995	2000
Pulp and paper	140	170	210
PVC	115	150	200
Chlorinated paraffin wax	72	80	100
Inorganic chemicals	65	70	75
Organic chemicals	40	45	55
Pesticides and Insecticides	39	45	50
Miscellaneous	30	40	50
Water treatment	16	25	42
Pharmaceuticals	15	18	20
Rayon grade wood pulp	10	10	10

Source: Hindu Survey of Industry 1995

Section 3 Uses of Elemental Chlorine

Chlorine is used in its elemental form as gas for water treatment and in greater quantities for bleaching in the pulp and paper and viscose rayon industries.

"All existing mills in the country are based on chlorine bleaching. Industrialists are not concerned with the generation of Total Organic Chlorine Compounds or Adsorbable Organo Halogens"

Central Pollution Control Board, India, 1991

3a Water Treatment

The introduction of filtration methods and chlorine as a primary and residual disinfectant in the late nineteenth century undoubtedly had a major impact on reducing illnesses and deaths from a number of waterborne diseases, including cholera and typhoid. Chlorination has also provided an important tool for combating a host of other pathogens transmitted through drinking water, including salmonella, giardia, schistomiasis, and even viral diseases such as polio and hepatitis. Until recently the use of chlorine as a means of rendering drinking water safe for human consumption had not been widely questioned.

3a.1 Does not kill.....

Since the mid 1970s scientists and health researchers have discovered a number of micro-organisms that are resistant to chlorine at the levels considered safe in drinking water treatment. In 1992 A.D. Russell established that a number of organisms, including strains of cholera, E.coli and the Legionnaire's disease bacteria were capable of adapting so that, "microbes could drift around unharmed in solutions designed specifically to kill them. Disinfectants such as chlorine and ammonia-based cleaners, soaps, fungicides, extremely salty or acid solutions, even high heat could all be withstood by hearty sporulant mutations" [21, Garrett, 1995].

Concern has focused around the micro-organisms known as protozoa and in particular cryptosporidium and to a lesser extent giardia. In 1993 an outbreak of waterborne disease in the city of Milwaukee, USA led to 400,000 people becoming ill and as many as 112 died. The source was identified as cryptosporidium in the city water supply. The water was adequately chlorinated. Subsequently scientists have established that this organism is impervious to chlorine at levels normally used in water treatment.

In India, where the source of cryptosporidium, human and animal faeces, is commonly prevalent in water, a high level of this protozoa is reported in the general population [22, Mathan, 1992]. But due to poor living conditions, its presence in patients with diarrhoea is often associated with other known pathogens and is not necessarily identified as having a causal role in their disease.

3a.2 .....And can kill

In the mid 1970s scientists realised that the reaction of chlorine with natural organic material in water created a whole range of chlorinated by-products, such as trihalomethanes including chloroform. Later it became clear that virtually every chlorinated drinking water supply is contaminated not just by chloroform, but by a host of chlorinated by-products [23, IARC, 1991].

At least half of the most commonly detected chlorinated by- products are rated by the USA EPA as probable or possible human carcinogens. Recent epidemiological studies have established a link between drinking chlorinated water and increases in certain types of cancer, such as cancer of the rectum, bladder and colon [24, Bull, 1990].

As a consequence certain countries, notably The Netherlands and Germany, are moving away from using chlorine as the automatic choice of water treatment disinfectant. In the Netherlands, chlorine has been effectively phased-out in favour of a combination of slow sand filtration, granulated active carbon and ozonation as a primary disinfectant.

However, in India we must be careful not to advocate reduction in chlorine usage, particularly in metropolitan areas, until well tested alternative systems are in place. Those responsible for ensuring the safety of drinking water face enormous problems treating their raw supply. Pressure

of population, hopelessly inadequate urban sanitation systems, faecal matter from domestic animals, industrial discharges and fertilizer and pesticide run-offs all contribute to contaminate surface and groundwater supplies. In these circumstances the use of chlorine keeps most waterborne diseases under control, even though it adds to the chemical burden.

All disinfectants, particularly the oxidants such as chlorine and ozone have their dangerous by-products. Ultra-Violet technology is expensive and energy consuming and only effective when the supply is relatively clean.

3a.3 Source protection

Policy to protect drinking water supply, both in the north, and India must focus on source protection, so that all final disinfectant treatment can be reduced. This means protecting water supplies from faecal contamination and stopping industrial use of precious waters as a means of diluting and hiding their wastes. The concept of "appropriate technology" should be applied to safeguarding supplies ensuring that traditional filtration systems at village and domestic level are adequate to ensure safe drinking water, without the need for chemical disinfection.

3b Pulp and Paper

The bleaching of pulp to produce white paper uses the greatest amount of chlorine gas in India - estimated consumption in 1995 is 170,000 tonnes or 26percent of total annual chlorine production [25, Hindu, 1995]. While large pulp mills are set to expand production to accommodate growing demand for paper products, the contamination of rivers and waters by massive discharges of highly poisonous organochlorines has been hardly addressed in India, indeed, almost totally ignored by industry. According to the CPCB, "All existing mills in the country are based on chlorine bleaching. Industrialists are not concerned with the generation of TOCI (Total Organic Chlorine Compounds) or AOX (Adsorbable Organo Halogens) [26, CPCB, 1991].

The chemical composition and impact of discharges from pulp mills using chlorine gas has been well documented worldwide, but not in India.

3b.1 Organochlorines in effluent

Over 300 organochlorines have been identified in the discharges of bleached pulp mills, including dioxins, furans, chlorinated phenols, acids, benzenes, and many others [27, Bonsor and al, 1989]. These identified compounds account for less than 10 percent of all the organochlorines in the effluent; the majority remain "mystery" chemicals that have not been specifically identified or assessed.

As discussed before, many organochlorines resist natural breakdown processes, so they build up over time in the environment. Organochlorines from pulp mills in Canada have been found in the water, sediment, and food chain as far as 1400 kilometres (868 miles) from their source [28, Environment_Canada, 1991]. Predator fish and other species near pulp mills have been found to accumulate dioxins and other organochlorines at concentrations thousands or even millions of times greater than the levels found in the water itself [28, Environment_Canada, 1991]. Dioxin contamination has forced the closure of fishing grounds around eleven of the fourteen pulp plants on the British Colombian coast, where extremely high dioxin concentrations were found in crabs, mussels and the liver tissue of fish [29, Greenpeace_Germany, 1992].

Pulp mills also release organochlorines into the air, particularly chloroform, a cause of cancer in animals [30, Shimp and Owens, 1993].

Organochlorines are found in the sludge produced at pulp mills. In forests where pulp mill sludge has been disposed, dioxins have accumulated in the tissues of field animals and have caused biochemical effects in birds [31, ERT, 1987].

Finally, organochlorines are found in paper products themselves. Environment Canada estimates that 2 percent of the organochlorines formed in the bleaching process remain in the pulp [27, Bonsor and al, 1989]. Dioxins and furans have been identified in cigarette paper, tampons, diapers, tissues, coffee filters and bleached milk cartons [32, Rappe, 1990]. Bleached containers and filters can leach dioxins into milk, coffee, and other foods with which they come in contact [33, Furst, 1991].

Box 3.1 DIOXIN

Dioxins have been listed by UNEP as a priority persistent organic pollutant for phase out

The term dioxin usually refers to a whole chemical family with 75 individual members, which more correctly should be termed chlorinated dibenzo-p-dioxins. The most toxic member of this family is 2.3.7.8-Tetra-Chloro-Dibenzo-p-Dioxin, often abbreviated to 2.3.7.8- TCDD. This compound is what the term "dioxin" usually refers to.

Often the term "dioxins" also includes a closely related chemical family called chlorinated dibenzofurans. The most toxic among the 135 known furans is 2.3.7.8 - Tetra-Chloro-Dibenzo-Furan (TCDF), which is one tenth as toxic as the corresponding dioxin TCDD.

Of the 210 dioxins and furans, twelve are extremely toxic. Their individual toxicity is ranked by comparing them to 2.3.7.8 TCDD via internationally agreed upon Toxic Equivalence Factors (TEF). The factor thus obtained (TEF) for each substance is multiplied by its amount or concentration and the results added together. The total is "TCDD equivalents" (TEQ).

In the world of synthetic chemicals dioxin is the most deadly and the most feared. Laboratory tests have shown dioxin to be thousands of time more lethal than arsenic to guinea pigs, who died after swallowing only one-millionth of a gramme per kilogramme of dioxin of body weight, and the most potent carcinogen ever tested on a number of animals.

In September 1994 the US Environmental Protection Agency (EPA) released a draft reassessment of human health risks from exposure to dioxin. The document warns that dioxin poses a large-scale, long term threat to public health - not only because dioxins are "likely to present a cancer hazard to humans", but also because they may have adverse effects on development, reproduction and the immune system at exposure levels close to those at which populations in the industrial north are currently exposed.

Dioxins are produced as unintentional by-products from the many processes in which chlorine and chlorine-derived chemicals are produced, used and disposed of. Even if creation of dioxins ceased now, levels in the environment will take years to decrease. This is because dioxins are persistent, taking decades or centuries to degrade, and can undergo continual recycling throughout the environment.

Human exposure to dioxins is almost exclusively from food intake, especially from meat, fish and diary products. In fish, mammals and humans, evidence shows that the developing foetus is most a risk. Animal experiments have shown that very low doses of 2.3.7.8 TCDD at critical times during gestation are enough to cause a reduction in sex organ weights, a decrease in sperm count and effects on sexual behaviour. The same dose had no demonstrable effect on the mothers.

3b.2 Harming the environment and health

There is extensive evidence that effluent from chlorine-bleaching pulp mills harms fish and aquatic ecosystems. Pulp mill discharges - and organochlorines in particular - have been linked to physical deformities in fish, reduced gonad growth, hormonal changes and reproductive impairment, liver disorders, disruption of cell function, changes in blood composition, damage to skin and gills, changes in shoaling behaviour and changes in the structure of fish populations. Organochlorine discharges from pulp mills have also damaged fish habitats, injured aquatic plant colonies, and caused harm to benthic and bivalve organisms [34, Sodergren, 1993].

Effects on fish have been recorded as far as 40 kilometres away from the pulp mill's discharge point [34, Sodergren, 1993].

An extensive study by the Swedish EPA was unable to determine any safe exposure level to organochlorine discharges from pulp mills, concluding that "regional and possibly large-scale" damage to fish and the aquatic foodchain may be occurring throughout the Baltic ecosystem [34, Sodergren, 1993]. Organochlorine contamination of the Great Lakes food chain has been linked

to region-wide epidemics of reproductive and developmental impairment in 14 species of fish and wildlife in that ecosystem [35, IJC, 1991].

Organochlorines found in pulp mill effluent can also harm human health. The U.S. Environmental Protection Agency, for instance, has estimated that people eating contaminated fish caught downstream from chlorine-bleaching pulp mills bear cancer risks as high as 1 in 50 [36, USEPA, 1990]. Several studies have found elevated risks of cancer among workers in the pulp and paper industry [37, Hogstedt, 1990].

3b.3 International Regulations on Pulp Mills

In response to these findings and growing public concern, both regulatory authorities and industry have tried to limit the impact of pulp mill discharges in the north. Lower limits have been set on the level of permissible AOX content that are impossible to meet by most existing technologies but a challenge for industry to make paper without contaminating the environment with organochlorines.

In February 1993 Ontario, Canada, required kraft bleach pulp mills (the most common type in India) to produce "AOX elimination plans", which would detail steps being taken toward the elimination of chlorine-based bleaching by 2002. The provincial government of British Columbia has regulations requiring the elimination of AOX discharges by 2002.

Box 3.2 AOX

AOX is a measure of the total halogen content (ie the halogen group of chemicals, including chlorine) of a waste stream. It is often used as an industry standard

However, AOX is not a test that will characterise the toxicity of any effluent stream, or characterise which organo-halogen compounds are being released. High levels of dioxin could be being released for example, but the AOX measurement would not indicate its presence. The Canadian Federal Government, in 1992, decided that "there was no scientific basis for setting an AOX parameter for controlling pulp mill discharges after finding that it did not provide a reliable estimate of persistence, bioaccumulation or environmental toxicity." [38, Carey, P. V. Hodson, 1992].

3b.4 Finding a solution

Large pulp and paper producers in environmentally conscious Sweden took the lead finding a solution. (Pulp manufacture is an important exporting industry for all Scandinavian countries). Helge Eklund, president of Sweden's largest pulp company, Sodra Cell outlined how they reacted to environmental pressure in a presentation to the Second Global Conference on 'Paper and the Environment in Frankfurt', April 1994:

"In 1987 the authorities demanded that our mills should reduce their emission levels of chlorinated compounds to 1.5kg of AOX per tonne of pulp. We reacted in the traditional way. We said, "No this is impossible to achieve with today's technology and besides it will be too expensive. Our costs will increase and our customers will not be prepared to pay more for our pulp simply because we have lower emissions than the remainder of the industry"....At the same time, chlorine-free bleaching technologies were being developed - Sodra Cell being among the main instigators. Slowly and surely the decision matured within our organisation to completely discard chlorine chemicals as a bleaching agent and instead replace them with considerably less aggressive bleaching chemicals.... We now broke with all the established industrial norms

concerning the environment, which started out from the basis of only doing that which is demanded by the authorities....We decided to say yes to the demands of the authorities and the environmental movement for chlorine-free bleaching, instead of no which earlier always lead to continual confrontation and gave us a bad image".

Today there are at least 55 mills producing Totally Chlorine Free (TCF) pulp world-wide. The majority are in Scandinavia, with a few in Spain and Portugal, seven in Canada and four in the USA [39, Pearson, 1992]. Chlorine-free bleaching is in the long-term economic interest of the paper industry. Because the alternatives are available and efficient, eliminating chlorine means changing processes, not closing mills or eliminating jobs. Conversion requires a capital investment, but a mill can offset that cost in just a few years through reduced expenses for energy, wastewater treatment, sludge disposal, liability and remediation [40, Singh, 1993].

Closing the Loop

Eliminating chlorine and its highly corrosive by-products allows a pulp mill to operate as a "closed-loop system"- continually recycling water within the bleaching operation. This reaps substantial further savings in water and chemical use. If all pulp mills followed this path there would be an annual saving of 24 billion gallons of water, [41, Shackford, 1992]. plus reductions of 90 percent or more in the use of other chemicals, such as caustic soda. With a closed-loop system, costs can be reduced by about 35 US dollars per tonne of pulp, or up to $3.5 billion per year for the entire industry [42, Albert, 1993].

ECF v TCF

Not all pulp industry in the north has gone TCF. Substantial sections of the industry, particularly in the USA, the world's largest manufacturer and consumer of pulp, are opting to go Elemental Chlorine Free (ECF); they use a less harmful compound of chlorine, chlorine dioxide, in order to reduce emissions.

However, chlorine dioxide still results in the production and release of large quantities of organochlorines, though less than chlorine gas. An average-sized pulp mill discharges around 35 tonnes of organochlorines every day, while those using chlorine dioxide discharge 7 to 10 tonnes per day [43, Solomon, 1993]. But in the words of Hans Burmeister, Marketing Director of Sodra Cell, "in ECF bleaching, chlorinated substances will always exist. They have to go somewhere and that somewhere will be a burden on the environment." [44, Burmeister, 1995].

Both camps, the chlorine dioxide (ECF) and total chlorine-free (TCF) technologists claim a closed-loop system is possible. But it is not possible to recycle wastes containing chlorine, because of chlorine's corrosive nature within the system. Therefore, either the chlorine wastes have to be incinerated outside the system or special dechlorinating equipment installed. In both cases hazardous chlorine compounds such as dioxin will be created.

Box 3.3 Pulp Mill Technology

All pulp mills operate on similar principles, using plant fibres consisting of cellulose bound together with lignin. Wood species have different contents of lignin, varying from 20percent (birch) to 30percent (pine).

Pulp mills in India almost universally use the sulfate (kraft) process. This is partly due to its applicability to almost all cellulose-containing raw materials; hardwoods such as birch, beech, eucalyptus and softwoods, such as spruce or pine, and non- wood annual plants such as bagasse (sugar cane residues), straw, reeds and bamboo.

The production of bleached sulphate pulp can be divided into two principle chemical processes; cooking and bleaching. In order to liberate the fibres from the wood, cooking of woodchips removes the bulk of the lignin, and the bleaching process eliminates the residual lignin. The cooking process takes place at 170 degrees centigrade, using caustic soda and sodium sulphate. The resulting pulp, after washing and screening contains some lignin and is a dark brown colour. The reason for chemical bleaching is to give the pulp sufficient brightness to meeting printing and consumer requirements.

Four Stages to Closing the Loop

1. The oldest production system uses elemental chlorine as its most important chemical agent. Increasingly, the less harmful chlorine dioxide is added to these systems.

2. Introduced in the middle of the 1970s, the second system is characterised by the introduction of oxygen delignification before chlorine bleaching, essentially shortening the bleaching time and allowing reduction in chlorine usage.

3. The third system evolved through pressure from environmentalists and regulatory authorities in about 1990. Elemental chlorine is replaced totally; through extended cooking and oxygen delignification. Brightness is achieved by using either chlorine dioxide or by other oxidising agents such as ozone or hydrogen peroxide.

4. The fourth stage has become technically feasible during the last three years; creating the so called closed-loop pulp mill, where wastewater is recycled within the bleaching operation. Thus drastically cutting down both on use of precious water, energy, chemicals and discharges of waste.

The debate between ECF/TCF approaches to reducing the environmental burden has passed largely un-noticed in India. Indian pulp technology remains in a time-warp, somewhere between the 1930s and mid-1950s and industry leaders are focused on expansion, with little thought to existing or further environmental damage.

3b.5 The Indian Pulp Mill Industry

The pulp industry is one of India's oldest. The first mill was set up a Serampore in West Bengal in 1832. But in terms of population the industry remains very small. Today there are over 300 mills producing about 2.5 million tonnes of pulp, of which about 10percent is pulp for the viscose rayon industry. This is not enough to cope with domestic demand and, in 1994, some 140,000 tonnes of pulp had to be imported.

Only one third of the pulp is made from wood, especially hardwood. The other two thirds are made from bamboo and agro-wastes such as bagasse and straw:

Table 3.1 Annual Pulp production in India.

1. Wood pulp for paper		850
Bleached hardwood	670	
Unbleached softwood	180	
2. Non-wood pulp for paper		1525
Bamboo	625	
Bagasse	520	
Straw	290	
Other fibres (jute, sisal, rags)	90	
3. Dissolving pulp for viscose		285
Total		2600

Source: FAO 1995

The mills are generally not large. Compared to Brazil or Sweden where the largest mills have a capacity between 300,000 and a million tonnes per year, the biggest mills in India hardly reach 100,000 tonnes. This poses potential financial problems for upgrading technology to reach international environmental standards.

There are about 90 small mills in India, with an average output of 10,000 tonnes per year supplying a total of about 900,000 tonnes of pulp. The raw materials of these mills are exclusively non-woods such as wheat and rice straw, jute, sisal and rags. A few of the small mills use bamboo. These 90 mills are producing for local demand, using inexpensive agricultural wastes. Geographically, they are more or less equally distributed throughout the country.

Of more importance, both in quantity and quality of production are the 25 larger mills, supplying about two-thirds of India's pulp, about 1.7 million tonnes per year. Wood, mostly mixed tropical hardwood and eucalyptus from plantations, is exclusively used by these mills. But they are not restricted to wood. All use bamboo, the most suitable among the annual plants for pulping, and even straw and bagasse. Bamboo accounts for nearly 60-70percent of tonnage.

The geographical centres of the hardwood and bamboo pulp industry are the four tropical southern states of Andhra Pradesh, Karnataka, Tamil Nadu and Kerala. 14 large mills are located in these states, producing 945,000 tonnes of pulp annually; 100percent of rayon grade pulp and almost 50percent of the total for quality paper.

Apart from the South, only in Eastern India is there any other significant capacity. There the government owned Hindustani Paper Corporation runs three of its five mills (two in Assam, one in Nagaland) with an annual capacity of 230,000 tonnes [46, Greenpeace, 1996]. .

See Annex B Pulp Mills in India

Environmental impacts of Indian Pulp Mills

Two key factors differentiate the environmental impact of Indian pulp production from developed (and many developing) countries:

- Indian pulp operations consume as much as 250-450 cubic metres of water per tonne of pulp compared to average water usage of 72 cubic metres achieved in 1988 elsewhere [17, TERI, 1995]. The most recent technology, installed in South Africa has a water demand of 16 cubic metres [45, Johnston, 1996]. CPCB allows a total waste water discharge of between 100 and

200 cubic metres per tonne of pulp, depending whether the source is from large pulp facilities, rayon and newsprint grade or agro-based.

- About 181.82 kg of chemicals are calculated as being needed to produce one tonne of paper in India [17, TERI, 1995]. Greenpeace Germany research estimates that as much as 90 kg of chlorine gas is used per tonne, because even the large mills, pulping and bleaching standards are low. Elsewhere chlorine usage is around 25kg per tonne and often to around 3-10 kg/tonne [45, Johnston, 1996].

This adds up to the fact that "water pollution is a major environmental problem of the pulp and paper industry" [17, TERI, 1995].

Up to now, not one of the larger pulp mills in India has progressed beyond Stage 1 to Stage 2 (see Box 3.3 Pulp Mill Technology) and included an oxygen process before bleaching. Only two mills generate chlorine dioxide in order to partially replace elemental chlorine in the first stage of producing pulp for pre-bleaching and the second stage as a replacement for hypochlorite. These mills are in Jaykapur (Orissa) and in Lalkua (Uttar Pradesh), belonging to Century Pulp and Paper and the J.K Corporation respectively. The two Assam mills of Hindustan Paper Corporation have chlorine dioxide generation plants but this is employed only as a final bleaching agent [46, Greenpeace, 1996]. . J.K Corporation is apparently planning to install ozone delignification in the first process stage.

Consequently, since nowhere in India at present has installed oxygen delignification after cooking, pulp mills require a lot of chlorine, mostly about 90kg per tonne of pulp and about 65kg where chlorine dioxide is used. Therefore, we have calculated that the average AOX discharge per mill would be around 8kg per tonne, perhaps higher; dropping to 5-6kg per tonne where there is partial use of chlorine dioxide [46, Greenpeace, 1996]. Most regulations in the north aim to achieve about 0.1 kg/AOX per tonne.

Greenpeace analysis: SIV Ltd

In Tamil Nadu, SIV Ltd (South Indian Viscose) at Sirumugai, near Coimbatore shot into notoriety after a marked increase in production in the mid-1980s resulted in colossal discharge of effluent into the Bhavani river, a vital irrigation source for farmers in central areas of Tamil Nadu [47, Rangajaran, 1996]. The company extracts 55 million litres of water daily from the river. and the current effluent stream size is 38,000 cubic metres per day.

People from numerous villages in the area were now forced to use so-called treated effluent for drinking water and irrigation. On May 9th 1994, more than three thousand villagers staged a day-long fast at the factory gate. Their drinking water was brown with lignin. No-one was told of the dangers of organochlorines. Fishery operations in nearby reservoir had come to a standstill. People from eleven villages had to abandon cultivation and take up stone cutting for a living.

The Tamil Nadu Pollution Control Board (TNPCB) temporarily closed the factory but the courts re-opened it soon afterwards on promises that effluent treatment would be improved. Nowhere, in the closure orders or High Court affidavits, is there mention of organochlorine compounds.

Now SIV Ltd plan to install an oxygen activated sludge process: "Using patented Linde process of activated sludge treatment of effluent using pure oxygen". This technique has beeen successfully implemented in 30 large pulp mills the world over and is guaranteed to give better than 95percent BOD (Biological Oxygen Demand) reduction and 75percent COD (Chemical Oxygen Demand) reduction." (Correspondence 4/10/95 between DR G.S. Keshavamurthy, Managing Director SIV Ltd and the TNPCB)

In all probability this process will not degrade persistent organochlorines. Indeed their presence may inhibit other biological treatment processes.

Greenpeace sampled and analyzed this effluent stream in May 1996. The following is an extract from the Greenpeace Research Laboratory Report:

> "The SIV plant, situated at Sirumugai near Coimbatore in Tamil Nadu, releases large volumes of organic-rich effluent to the channel of the Bhavani River. Analysis of an effluent sample revealed contamination with a complex mixture of primarily phenolic compounds (Box 3.4 Chlorinated Phenols) . Of 56 compounds isolated, identifications were obtained for only 14, and of these only 6 are considered reliable.
>
> Of the compounds reliably identified, nonylphenol and 2,3,5-trichlorophenol are of particular interest. The toxicology of trichlorophenols is described in the Box 3.4 Chlorinated Phenols. The toxicity of nonyl phenol, and related alkylphenols, is still relatively poorly understood. No information is available on the toxicity of the other compounds identified.
>
> Alkylphenols (APs) may arise from a number of different industrial processes, including the use of alkylphenol ethoxylates (APEs) as detergents, or their direct use as lubricants or as additives in the manufacture of certain polymers. Although APEs are readily degraded to APs, the latter are highly persistent [48, White, 1994]. [49, Argese, 1994]. Acute toxicity of alkylphenols in laboratory bioassays have been demonstrated. Perhaps of greater significance are the recent demonstrations that APs, particularly nonylphenols, can interfere with hormonal systems, specifically by binding to the oestrogen receptor in both fish and humans [48, White, 1994], [50, Routledge, 1996].
>
> The potential for effects on human and wildlife populations resulting from high volume discharges containing nonylphenol and related compounds merits serious consideration, particularly as the effluent is becoming increasingly used for the irrigation of arable land. A study by Swaminathan et al [51, Swaminathan, 1992]. about effluent from plant to irrigate ground-nut plantations reported severe inhibition in the development of seedlings, resulting in a 93percent reduction in seedling height, 67percent reduction in root growth, 71percent decrease in chlorophyll content of the mature plant and a corresponding reduction of 55.4percent in carbohydrate content and 39percent protein content of the crop."

SIV Ltd is planning further expansion, to increase capacity of dissolved grade wood pulp from 145 to 250 tonnes per day (tpd). Chlorine usage will increase from 4.5 to 8 tpd. The effluent will be used for irrigation:

"As directed by TNPCB, we have laid out a pipeline network for distribution of treated effluent to farmers in the Annadasampalayam and Koothamandi area at the cost of 40 lakhs (120,000 USD). Presently about 180 acres of land are being irrigated with our treated effluent. The healthy turn out of crops has been reported by all the users of our treated effluent and bumper crops of soya have been harvested. We are extending the area of irrigation to cover about 2000 acres of land." (Correspondence 4/10/95 between DR G.S. Keshavamurthy, Managing Director SIV Ltd and the TNPCB)

It is interesting, therefore, that the same effluent that deters the growth of ground nuts, appears to improve the growth of soya. Note, however, that in the use of the effluent for irrigation purposes, no consideration appears to have been given to the long-term accumulation of persistent organic

pollutants, such as those identified above, in the soil, nor to the accumulation of organic residues in the crops themselves.

3b.6 The Central Pollution Control Board and Pulp Mills

The CPCB has placed a maximum level of 2kg of TOCl (Total Organic Chlorine Compounds) per tonne of pulp (applicable since January 1992) in its Environmental Protection Rules, 1986, governing effluent discharges from Large Pulp and Paper and Rayon Grade Plants.

Given the standards of technology employed it is difficult to see how this standard can be achieved. The CPCB, in its Comprehensive Document for Large Pulp and Paper Industry, 1991, recognised that, "Bleach plant effluent is the dominating source of the pollution in the industry" and outlined three ways to reduce these discharges:

- Partial or complete recycling to the recovery system to destroy the organic material in the effluent.
- External treatment of the effluent to remove organic material.
- Use of bleaching chemicals which give rise to less polluting materials, e.g. oxygen, chlorine dioxide.

It recognises that, "chlorine content of the effluent and chloride build up in the recovery system drastically limits the possibilities of recycling bleach effluents" and that only with the adoption of a new delignification process, "like the use of oxygen in bleaching", will it be possible to recycle wastes.

Since at that time no Indian pulp mill had installed such a system, the CPCB had to recourse to giving advice on a combination of methods of treating wastewater, physical, physico- chemical and biological, "to reduce all pollutants to regulatory standards". But treatment of waste waters does little to reduce the chlorine loading on the environment. That can only be achieved by reducing the amount of chlorine used in the system.

Burnison [52, Burnison, 1996]. recently described pulp mill effluents as comprising "a myriad of chemicals that have the potential to cause deleterious effects on aquatic biota in receiving waters". As many of these chemicals are highly persistent, particularly those resulting from chlorine bleaching of the pulp, simple dilution of the effluent is not effective as a pollution control strategy [53, Nyholm, 1996].

These persistent chemicals are also frequently poorly degraded in conventional biological treatment systems, and may even be inhibitory to such processes [54, Boyden, 1994]. [55, Stephenson, 1996]. In addition, partial degradation of high molecular weight chlorinated lignins may generate lower molecular weight products of higher bioavailability and, therefore, toxicity [56, Fukui, 1992].

CPCB and Chlorine Free

The CPCB therefore seems to recognise that in order to reduce organochlorine discharges from pulp mills, there needs to be a process change in the amount of chlorine used. [26, CPCB, 1991].

"5.3.1. The discharge of Total Chloro-Organic Compounds (TOCl) is to be limited as the Ministry of Environment and Forests has also stipulated the standards of TOCl at 2kg/tonne of the pulp (applicable from 1992). The aforesaid limits could be achieved by internal control measures such as:

(a) Better process control (for example control of chlorine loads etc.).

(b) Modified pulping in combination with oxygen delignification in order to reduce the kappa number before bleaching process. (The kappa number expresses the lignin content that has to be bleached away).

(c) Efficient washing of the pulp before bleaching.

(d) Replacement of chlorine by other bleaching agents, such as chlorine dioxide, hydrogen peroxide etc.

(e) Addition of oxygen/peroxide reinforced alkali stage during bleaching process.

"If the above measures are incorporated in a right manner, it is possible to reduce generation of TOCI to the desired level from bleached pulp mill effluent.

"It is also revealed that the discharge of dioxin in particular can be reduced by taking more or less the same measures which would reduce TOCI discharge. Low levels of chlorine multiples seem to be of importance in this context. These measures to eliminate the formation of dioxins are currently being introduced in all kraft mills in developed countries."

Chlorine: What problem?

Further in the same document, the CPCB states: "..there is currently a lack of knowledge on the long-term effects of discharges of chlorinated organic compounds from the bleacheries. This is unsatisfactory, bearing in mind the extent and nature of the discharges"

Even in 1991 there was enough evidence (summarised above) from research done on bleaching operations elsewhere to conclude that bleaching operations using lesser amounts of chlorine than Indian pulp mills were having a devastating effect on waters, fish and wildlife.

The CPCB goes on to say "....there is a shortage of technical solutions which could eliminate the discharge of chlorinated organic compounds. It is, therefore, uncertain how the long-term objectives such as elimination of chlorine are going to be achieved".

By 1996 The CPCB had researched a number of low-cost solutions, mostly based on the use of solvents in pre-bleaching processes, that could enable chlorine-free bleaching to take place. A small number of pilot programmes are currently in progress [57, CPCB, 1996]. Certainly it is not technically possible to move to chlorine-free bleaching unless a none chlorine-based delignification process takes place before bleaching (see Stage 2 of Box 3 Pulp Mill Technology).

There seems to be either little concern by the Indian pulp industry about their discharges of organochlorines or plans for investing in technology that will eliminate the use of chlorine. According to Mr Rastogi of the National Productivity Council, "Chlorine-free technologies are not available in India and if someone wants to use them, they have to be imported which might be very expensive for industry". He added, " And why should they change the technology when there is no pressure from the government or otherwise. Also when it is difficult to ascertain the damage being done to the environment as there is a lack of availability of testing facilities in many of the areas where these industries are located." (Interview October 1996).

John Thomas, Assistant Director of the Environmental Division of the National Productivity Council, reinforced these views, "AOX test facilities are few and its not considered an important parameter". (Interview October 1996)

When a comprehensive cleaner production audit was conducted at J.K Paper Mills, Rayagada, Orissa in March 1996 by the National Productivity Council, under a table of Cleaner Production Indicators, AOX, as well as residual chlorine, were not even quantified as part of the pollutant

load. This is extraordinary considering that discharge of organochlorines from the bleaching process is recognised as the most environmentally damaging part of the pulp mill process.

U.P Singh, Senior Environmental Engineer at the CPCB confessed that since the 2kg per tonne/TOCL limit was place on pulp mills in 1992 not one of the State Pollution Control Authorities had installed facilities to test for this parameter. (Interview 10/10/96), It was now being abandoned and samples from mills were now being taken and analyzed to establish an AOX limit.

Quite simply, nothing has been done until now to control or regulate discharges of organochlorines from pulp mills. As we have seen, efforts to use wastewater for agricultural purposes are fraught with danger. Even though the CPCB recognises that the only answer is to move out of chlorine bleaching, little has happened. There are few indications that the situation will improve. The CPCB seems totally impotent in this regard.

There are only two AOX testing facilities in India. One with the CPCB and the other with the industry funded Central Pulp and Paper Research Institute at Saharanpur, Uttar Pradesh. No doubt the latter are sampling to see what level industry will accept rather than what environmental protection demands.

3b.7 Expansion and Profit

The priority of the pulp and paper industry in India is to expand production and increase profitability.

Even among developing countries, Indian consumption of paper is quite low at 3.2 kg per person per year as compared to 11kg in Indonesia, 14kg in China and 40 kg in the Asia Pacific region. In Japan and the U.S., it is 220kg and 309kg respectively [25, Hindu, 1995]. .

Liberalisation and globalisation of the Indian economy offer new opportunities for upgrading of technology and raising output. Even a modest increase in the per capita consumption to 5kg will boost consumption to over 5 million tonnes per annum by the turn of this decade", says Mr Harsh Pati Singhania, Chairman, Indian Paper Makers Association (IPMA) [25, Hindu, 1995]. .

Currently the industry is facing threats from cheaper foreign imports of both pulp and paper. Import duty on paper was cut from 65- 20percent in May 1995. Sinar Mas are importing large quantities of pulp from Indonesia and are planning to install a mill with a capacity of 900 tonnes per day at Bhigwan Taluka, near Pune, Maharashtra [58, ET, 1996]. .

More raw materials needed

Indian industry is also faced with the problem of obtaining further supplies of raw materials. Forests in India occupy 75 million hectares, which is nearly 24percent of the total land area of the country. This is well below the minimum requirement of forest cover, which is around 33percent. The availability of bamboo is getting scarcer day-by-day. "With its bloated import bills and few substitutes, the industry requires forest lands to meet its raw material needs", says PV Mehta, Executive Director of the Indian Plywood Industry [59, FE, 1995].

The Ministry of Environment and Forests has proposed leasing out forest land to the pulpwood industry. This has triggered widespread protests and condemnation by environmentalists, who fear it would alienate the country's 150 million forest dwellers and jeopardise forest conservation. Currently the battle is focused on the decision of the Madhya Pradesh Government to offer 3,500 hectares of forest for private tender. This is being opposed by villagers threatened by the ending of traditional livelihoods and displacement.

According to the Expert Committee constituted by the Development Council for paper industry, the industry would need 81.5 lakh tonnes of pulpable wood per annum by 2000 A.D. This calls for fresh plantations of pulpable wood over an area of 16.4 lakh hectares in the next few years. "To augment the diminishing pulpwood it becomes imperative to create an additional resource base in the form of close spaced plantations of fast growing species with optimum fibre content, located within economic distance of the mills."

It is therefore desirable that the paper industry considers utilising other alternative sources of raw material. Of these, bagasse has the largest potential for use in paper making. India has over 270 sugar mills providing around 46 lakh tonnes of bagasse per year. Often this goes to waste or is burnt in the ovens of sugar mills [60, Kotharis, 1994].

Profit without Environmental Protection

Despite these potential problems of supply, the pulp business in India is booming. From the first half financial results of the top 30 pulp companies in 1995/6 we can see that sales income has increased to R2,489 crore (7.5 billion USD), up 22.7percent. The operating profits of the 30 companies were up by 49.2percent, with companies such as West Coast Paper, AP Paper, Orient Paper, Shree Vindhya Paper, Seshasayee Paper, Star paper and Sirpur Paper enjoying well over one hundred per cent profit.

The Centre for Monitoring the Indian Economy (CMIE) data shows that 45 expansion projects with an investment of R6,000 crores (18 billion USD) is likely to add about 17.7 lakh tonnes to capacity [61, BS, 1996]. In the light of this profitability, the pulp and paper industry's failure to address major environmental concerns should be a national scandal.

Greenpeace analysis of Pulp Mill effluent

Greenpeace collected samples from the main effluent discharges of three large pulp mills in May 1996.

a) Seshasayee Paper and Board Mills, nr Erode, Tamil Nadu.

b) Bellapur paper mill, Yamunanagar, UP.

c) Central Pulp Mills, Fort Songadh District, Surat, Gujarat.

For each waste stream, non-polar to semi-polar organic contaminants were identified by GC/MS (gas chromatography/mass spectrometry) after extraction in analytical grade pentane. Note that this standard extraction technique will not recover the more polar chlorinated and non-chlorinated contaminants which may form a large proportion of the organic loading of the wastewater from bleached pulp mills. Indeed, much of the organic fraction may be present as high molecular weight refractory material which cannot be analyzed using conventional GC/MS. The technique employed will, therefore, give only some indication of the nature and levels of contaminants in the effluent and, hence, the toxicity associated with the discharge; the range of compounds reported and the overall effluent toxicity are likely to be underestimated as a result.

a) Seshasayee Paper and Board Mills, Tamil Nadu.

Of 21 compounds isolated from this waste stream, only 5 could be identified reliably. These included three organochlorines, 1,1,2,3,3-pentachloro-1-propene, 2,4-dichlorophenol and 2,3,6-trichlorophenol, all of which are both acutely and chronically toxic to aquatic life, humans and other animals. Such substances are commonly formed as a result of the chlorine bleaching of wood and other pulps. Very little toxicological information exists for pentachloropropene; in contrast the toxicity of chlorinated phenols has been well documented

(see Box 4 Chlorinated Phenols). 9,10-Anthracenedione, also reliably identified, appears to have low systemic toxicity, but may act as a skin irritant and sensitiser [62, Merck, 1989]. .

A number of other chlorinated organic substances were tentatively identified in the effluent, along with long-chain organic acids typical of pulp effluents. Although inspection of their mass spectra confirmed their identity as organochlorines, their precise identities are less certain. In this case, as with many complex effluents in which a large proportion of the chemicals isolated cannot be identified, it is impossible to make any predictions as to the likely toxicity of many of the individual components or of the effluent as a whole [45, Johnston, 1996]. .

b) Bellapur Mills, Yamunanagar

Again the effluent yielded a complex mixture of organic compounds, with long-chain hydrocarbons and fatty acids particularly abundant. The presence of organic compounds of sulphur, derived from the pulp material, is indicated by the positive identification of dimethyl tetrasulphide and the appearance of sulphur as a broad peak between 25 and 30 minutes on the chromatogram. In addition, both 2,4,6-trichlorophenol and dichlorophenol (possibly 3,4-) were detectable in the effluent.

Again, typically for complex waste streams, reliable identifications were obtained for only a small proportion of the total number of compounds isolated (14 of 47, or 30percent).

c) Central Pulp Mills, Gujarat

Here the main effluent discharge was more complex again than those described above, in terms of both the number (64) and range of compounds isolated. The higher complexity may relate to differences in the raw material used for pulping, or in the pulping and bleaching processes themselves. Of 26 compounds reliably identified, 8 were organochlorines. Again di- and trichlorophenols and pentachloropropene were present at significant concentrations, along with a derivative of tetrachlorophenol and 3,4,5-trichloroguaiacol. The chlorinated guaiacols, along with 2,4,6-trichlorphenol, are among the most resistant to degradation and, therefore, most persistent in the environment of the low molecular weight organochlorines commonly formed during the chlorine bleaching of pulp [63, Palm, 1995].

The chloroguaicols have been shown to bioaccumulate up to 100-1000 times in animal tissues and inhibit kidney function in rats [64, Oikari, 1995].

The identities of the other organochlorine chemicals listed are less certain. Of particular interest is a contaminant tentatively identified as 1,2,3,4,5,6-hexachlorocyclohexane (HCH). Visual inspection of the mass spectrum for this analyte confirmed good matching with that of HCH, although to our knowledge the formation of this compound during pulp bleaching has not previously been reported.

The presence of significant concentrations of organochlorine chemicals, and other complex organics, in this effluent stream is of particular significance to human health, as women and children were employed to work for long periods immersed in the effluent, without protective clothing, in order to clear sediment from the discharge channel. Many of the organochlorines identified, particularly the chlorinated phenols, are readily absorbed through the skin (see Box 3.4 Chlorinated Phenols).

Box 3.4 Chlorinated Phenols

Di- and trichlorinated phenols, along with more complex chloroguaiacols, are common contaminants in the effluent waste streams of pulp mills employing chlorine bleaching [63, Palm, 1995]. Their relative toxicity and persistence depends on the precise chemical structures, in particular the location of the chlorine substitutions around the phenol ring.

Although slightly soluble in organic solvents such as pentane, di and trichlorophenol are particularly soluble in water. It is likely, therefore, that our analyses would have recovered a maximum of 5percent of the total amount of chlorophenols present in the effluent samples.

Chlorinated phenols are relatively persistent toxic substances. Toxicity is generally reported to decline with the degree of chlorination, trichlorophenols being more toxic than dichlorophenols, etc. [65, Zhao, 1995]. The toxicity of dichlorophenols may be as much as 50 times greater as that of phenol to some organisms [66, Muller and Herbarth, 1994]. In fact, 3,5-dichlorophenol is frequently selected as a standard toxicant for the calibration of toxicity bioassays [67, Hutchinson and al, 1995], [68, Strotmann and al, 1996].

Many chlorophenols, particularly the higher chlorinated forms, are potent developmental toxins even in human cell lines [69, Narasimham and al, 1992]. , [65, Zhao, 1995]. Witte et al [70, Witte and al, 1996]. have recently demonstrated highly complex interactions between chlorophenols and other contaminants administered to human muscle cells, including some toxic responses which were greater than additive (ie. Synergistic). In many cases, the toxicity of chlorophenols appears to result from their interference with fundamental biochemical processes in cells [69, Narasimham and al, 1992], [71, Penttinen and al, 1996].

2,4-Dichlorophenol, identified in effluents from both Seshasayee and Central mills, is rapidly absorbed through the skin, whether as the pure chemical or dissolved in water, and enters the blood stream [72, USPHS, 1992]. Although a single dose may have a relatively short biological half-life in humans (2-3days), long-term or repeated exposure to significant doses may lead to permanent damage to the skin, eyes, liver, and kidney. Nagyova and Ginter [73, Nagyova and al, 1995]. reported a decline in liver enzyme activity in guinea pigs exposed chronically to this compound. Furthermore, although biological half life may be short, Veningerova et al [74, Veningerova and al, 1994] were able to demonstrate consistently higher levels in exposed workers.

Small quantities of the pure chemical applied directly to the skins of rabbits induced lethargy and produced sores around the area of application, even over periods as short as 1 day. Over the same period, larger doses applied to the skin induced convulsions, breathing disorders and death in laboratory animals. There is also some evidence that 2,4-dichlorophenol may be toxic to the immune system and may harm the unborn foetus as a result of maternal exposure [72, USPHS, 1992].

Relatively little is known of the toxicity of 2,4,6-trichlorophenol, and even less of other trichloro- and tetrachlorophenols. 2,4,6-Trichlorophenol (identified in the effluent from Central Pulp Mills) can enter the body through ingestion of contaminated food or water and directly via absorption through the skin, although its fate in the body via skin absorption is poorly understood. Chronic exposure to this compound has been shown to induce changes in the cellular structure of the liver and spleen of laboratory animals, as well as decreasing the number of offspring and the average birth weight following exposure of the mother [75, USPHS, 1990].

The presence of trichlorophenols is often considered to be an indicator for the presence of polychlorinated dibenzodioxins and dibenzofurans, commonly termed dioxins and furans. Indeed, chlorine-bleached pulp effluents have long been identified as important sources of dioxins to the environment [76, Henshel and al, 1995]. , [77, McLeod, 1995].

Both 2,4-dichlorophenol and 2,4,5-trichlorophenol are suspected human carcinogens; the former promotes the development of tumours induced by other agents in laboratory mice [72, USPHS, 1992]. 2,4,6-Trichlorophenol is a confirmed carcinogen in animals [78, Sitting, 1994]. All three are considered to be probable or possible human carcinogens. Data from epidemiological studies of cancer rates in exposed workers are generally of limited value in determining causality, since in most cases workers exposed to chlorinated phenols are also occupationally exposed to a wide range of other potential carcinogens [72, USPHS, 1992]. .

Some degradation of chlorophenols, particularly the lower chlorinated forms, may take place in effluent treatment plants, where they exist, although these generally need to be designed specifically to remove chlorinated organics [79, Hall and Randle, 1994], [80, Duff and al, 1995], [81, Puhakka, 1995], [82, Gonzalez, 1996]. It was not possible to determine the presence or nature of such treatment plants at any of the mills above. In fact, dichlorophenol, and even more so its primary photodegradation products, may be toxic to activated sludge organisms [83, Manilal and al, 1992], [84, Lang, 1994], [85, Strotmann, 1995] demonstrated that shock loading of biological treatment plants, designed to reduce BOD and COD in wastewaters, with dichlorophenol resulted in inhibition of bacterial activity. Similarly, [86, Gu, 1995]. reported reduction in bacterial activity in a treatment plant exposed to di- and trichlorophenols, while Limbert and Betts [87, Limbert and al, 1995]. found that the presence of a complex mixture of chlorinated and non-chlorinated organic compounds in an effluent stream could increase the vulnerability of the bacterial cultures to toxic shock from other compounds.

Money for cleaner technologies?

At least two of the companies owning these three plants sampled have plans to expand operations; seemingly with plenty of investment funds:

- Seshasayee has secured a "no objection" certificate (NOC) from the Tamil Nadu Pollution Control Board to enhance the capacity of its mill near Erode, Tamil Nadu from 60,000 to 120,000 tonnes per year at a cost of Rs33,416 lakhs (100 million USD). The Industrial Development Bank of India has sanctioned a loan of Rs8000 lakhs (24 million USD) and a guaranteed assistance of Rs4443 lakhs (13.4 million USD) against foreign suppliers credit. The Finance Corporation of India Ltd (IFCI) has sanctioned a loan of Rs4000 Lakhs (12 million dollars).
- Ballarpur Industries Ltd (BILT), flagship of the Thapar Group, the countries' largest producer of paper and currently ranked 57 in a list of India's most valuable companies [88, BT, 1996]. is also enjoying prosperity. It claims, in its annual report, to be celebrating its best ever year. Profits have increased by 63percent (to Rs142.3 crore, 43 million USD), the return on capital has gone up by 35percent, and exports by 45percent.

Ballarpur is planning a huge expansion programme. It intends to increase its production to 400,000 tonnes of pulp per year in the next three years from a current capacity of 275,000 tonnes . It is to expand and modernize its five mills between 1995 and 1998, at a total cost of Rs12,645 million (about 380 million USD). These projects include a joint venture with Stora of Sweden for a board mill and increasing pulping capacity at its mill at Ballarpur in Maharashtra from 300 to 370 tonnes per day and adding a 115,000 tonne per year bamboo and hardwood pulp line in the same location [89, ET, 1996].

BILT claims to operate "some of the most eco-friendly manufacturing units in the country, reflecting BILT's concern for the external environment."

Other companies planning expansion include, Century Textiles (added capacity 84,600 tpa), TNPL (90,000 tpa) and Sinar Mas (100,000 tpa). Indo Gulf, NEPC and many others have also announced a host of plans.

Somewhere in these mounds of rupees there should be sufficient funds to install technology that will set the Indian pulp industry on the road to a total chlorine-free future, thus considerably lessening the organochlorine burden on the environment and people of India.

3b.9 Appropriate Development: The role of the paper industry

Companies such as BILT adopt northern models of behaviour. According to company policy, any business in the BILT group that does not generate a return of Rs25 crore and 25percent on capital employed deserves to be shut down. It's called the 25-25 rule within the company. Trimming flab, cutting costs, de-layering; all the modern corporate codes of behaviour are being adopted to maximise profits and increase production. Consultation with international paper giants such as Stora and International Paper showed BILT that the labour required in India to run a plant is far in excess of what automated plants in the US require. BILT decided to go for a 'major voluntary separation scheme', and close to 1500 employees accepted. Today, the company has reduced its managerial force by 25percent and its labour force by 20percent [89, ET, 1996]. To serve its raw material needs, BILT has been engaged in an effort to persuade the Government of India to facilitate private plantations.

Is this a wise model for India, traditionally a rural village economy with many hands available for work and many mouths to feed? Consultant Anita Kerski shows, how the pulp and paper industry creates dispossession, deforestation and pollution tied to a dynamic of ever increasing scale and capital intensiveness [90, Kerski, 1996].

Far from responding to consumer demand, the emphasis on "efficiencies" in the pulp industry mean an ability to produce as much paper as possible as cheaply as possible. New markets are sought and moulded to production, paper shirt collars, underwear, drinks cartons, nappies, toilet paper and export packaging. In 1991, over 40percent of world paper production was used for packaging and wrapping, while only 30percent went for printing and writing and 13percent for newsprint, with increasing volumes from all three categories going for advertising.

Per capita paper consumption is therefore not so much an index of literacy but a measure of the paper industry's success in finding new markets, in particular for packaging. Should India try to match the gross over consumption of paper of the north or balance pressure on scarce resources such as forests with societal needs for books and newsprint. Government needs to curb market forces by utilising fiscal instruments that limit the growth of non-essential paper usage such as packaging, advertising and "junk mail".

Pulp mills find it difficult to share the landscapes they occupy with the local communities pursuing a variety of agricultural, fishing and subsistence-gathering activities. Large mills work better with simplified, compact populations of factory-friendly trees, for example, than with native woodlands reserved for a variety of uses. They favour the growth of mill towns where everyone works for the industry rather than communities with diverse livelihoods. Efficiencies of production for the industry can well be a loss to a farmer of fodder, fish, clean soil and water and an entire way of existence.

The Indian hand-made paper industry

Handmade paper production units are amenable to decentralization. Small units can be easily installed in rural areas, even areas with limited access to water and electricity. Raw materials would be biomass materials and agricultural wastes; transportation to centralized mills is too costly for large producers. Handmade units in urban areas presently use exclusively cellulose-rich materials such as cotton rags and waste paper but can also use wastes such as straws, rice husks and grasses.

According to the Khadi & Village Industries Commission, the combined production of 310 working handmade paper production units in India amounts to some 7000 tonnes per year. This sector produces goods valued at 2.5 million USD per year and employs 5300 people. There is a huge potential for expansion.

Handmade paper units are environmentally more sound than either large or small-scale conventional processes;

- Pulping is done mechanically and there is no need of hazardous chlorine or other chemicals.
- Water consumption is much lower.
- Large-scale units consume an average of 2.5 tonnes of forest- based raw materials per tonne of paper. Small scale units consume an average of 3.5 tonnes of raw materials; mostly ago-based. Handmade units consume only 1.1 tonnes, since waste generated in the process can be internally recycled without loss of quality.
- Handmade paper production does not require large-scale capital investment. Therefore, employment creation needs only one tenth of the capital per person compared to a large-scale unit.

- Handmade paper can be tailored to the exact needs and requirements of clients . [91, Subramanian and Kumar, 1994].

Clearly handmade paper will only serve a fraction of India's paper needs but this type of decentralized operation, using mechanical non-chemical processes, recycling water and renewable agro-wastes as raw material is a more appropriate developmental model for India.

Section 4 Products made with Chlorine

"The pesticide industry world-wide is unlikely to affect the Indian industry despite the reduction in import duties in March 1993. Because of environmental constraints, most of the international plants are closing down and this would ensure that the pesticide industry domestically will continue to prosper."

R.D. Shroff, Managing Director, UPL Ltd
"specializing in hazardous, poisonous and flammable substances"

Introduction

Looking downstream, beyond the uses of elemental chlorine for water treatment and bleaching operations, the uses of chlorine in organic and inorganic chemistry and as an intermediary in chemical processes becomes increasingly complex.

Even at the chlor-alkali process stage, part of the chlorine and part of the caustic can be combined into salts such as sodium chlorite ($NaClO2$) and sodium hypochlorite ($NaOCl$). Solutions of these products in water are less dangerous to handle and transport than chlorine. They are likewise used as a bleaching agent and for disinfection and can be used to release chlorine by adding hydrogen chloride.

Chemical combinations create many diverse products using chlorine. Small amounts are used to produce metal chlorides like aluminium chloride ($AlCl$ - a well-known catalyst); titanium chloride ($TiCl4$ - a smoke screen agent); iron chloride ($FeCl$ - used in water treatment, as an etching agent and agent for phosphate removal); metal oxides (e.g. Titanium dioxide, $TiO2$ - an important white pigment in the paint, plastic and paper industries); and pure metals like titanium (for airplanes and ships), iron, magnesium, aluminium, silicon and boron.

By the replacement of hydrogen atoms in hydrocarbons by chlorine atoms, and with the help of chlorine or hydrochloric acid HCl, literally thousands of new compounds can be and have been synthesised. The most common feedstocks are oil derived methane and ethane.

Whatever the combinations, chlorine + carbon = organochlorines.

Chlorine appears in about 15,000 chemicals; that is about 25percent of the estimated 60-70,000 chemicals in commercial use today. If you add all those compounds for which chlorine is used in the manufacture but is not present in the final product, then the number would be much larger. No reliable statistics of this latter category are available [92, MIT, 1993].

Organochlorines are created either by design in industrial chemistry for products such as plastics, biocides, adhesives, paint removers, aerosols etc., or as an accidental by- product of chlorine chemistry, for example when chloroform is formed by the reaction of chlorine and organic matter in fresh water or dioxins formed in pulp mill waste-streams or by burning PVC cabling wastes in smelters to recover copper.

4a Chlorine based products prioritised

A diverse and plentiful array of products are made using chlorine, all of which will impact on our lives either by ingestion, or inhalation or from inheritance: eating food containing pesticide residues, or dairy products found with increasing levels of dioxins; or drinking water contaminated by solvents; or breathing air from incinerators burning chlorinated waste products.

We have outlined three main categories of product, adapted from a document drafted for consideration by the European Commission by Vonkeman and Maxon [93, Vonkeman and Maxson, 1991]. These three categories are in descending order of exposure or potential exposure to the environment, from production processes using chlorine: products where chlorine is used in the manufacture but is not in the final product; products containing chlorine where chlorine is unintentionally emitted to the environment; products containing chlorine where chlorine compounds are intended to reach the environment.

First, however, organochlorines that occur naturally in the environment are described.

Naturally occurring organohalogens

In contrast to the thousands of organohalogens (mostly organochlorines) produced by the industrial use of chlorine, nature produces some 1200 in total, mostly in small quantities: created by algae, fungi and bacteria and in the marine environment by marine invertebrates such as the sponges, corals, and molluscs, insects and higher plants. They are also released into the biosphere by natural combustion processes, plant and forest fires for example. The quantification of these is unreliable and the quantities emitted may be enhanced by the widespread use of organochlorines such as the herbicide 2,4-D and the insecticides DDT and dieldrin in forestry [94, Stringer and Johnston, 1995].

Only one organochlorine, chloromethane, is produced by nature in excess of man-made inputs (an estimated 26,000 tonnes per year); a relatively simple compound, it evidently plays a role in the natural regulation of the ozone layer [95, Thornton, 1991].

Our understanding of the creation, structure and function of natural organohalogens is still embryonic, but it is already apparent that they have considerable biological activity and functions that are essential to the survival not just of individual organisms but of species and ecosystems Indeed, in the light of scientific findings, there can be no justification for saturating natural organohalogen budgets, with man made halogenated compounds. [94, Stringer and Johnston, 1995].

4a.1 Chlorine not in final product

Production where chlorine is used as an intermediate but is not present in the final product.

This category covers about 50percent of chlorine used in industrial chemical processes in Europe and possibly about 20percent of chlorine usage in India, although available figures are not process specific.

In the end, most of the chlorine leaves the process as an inorganic chloride (salt), or as hydrogen chloride (HCl) that can be reused. These include:

- Methyl chloride (monochloromethane) is an intermediate for many materials including silicones, methylcellulose, tetra methyl lead and higher chlorinated methanes.

- Allyl chloride/epichlorohydrin is used to produce epoxy-resins that are applied in paints electric insulation, laminates in electronics, adhesives and composite materials for airplanes.
- Oxidised chlorine products are intermediates in the production of inter alia poly-propyleneglycol, polyether and poly alcohols, finally resulting in polyurethanes (car industry, furniture, shoes, textile, packaging material, thermal insulation in buildings) and carboxymethylcellulose (food, cosmetics, glues, oil industry).
- Benzyl chloride is a reactant in the pharmaceutical industry for the production of amphetamines, phenobarbital and many other medicinal compounds.
- Phosgene is reacted with diamines in the preparation of di-isocyanates, which are then reacted with glycol in another route to form polyethanes. It is also the intermediate in the production of polycarbonates and is an important engineering plastic in the car industry, production of household apparatus, artificial glass.

Industry often states that these types of processes have little relevance to the chlorine problem. However, in the first place, the processes have sometimes extremely dangerous intermediates, like vinyl chloride monomer (carcinogenic), and phosgene (a well- known war gas). In addition, losses and by-products will always occur and chlorine containing emissions and waste cannot be avoided. Even minor percentages can be meaningful given the large volume of production and the nature of the substances. This sector of chlorine use is a significant contributor to chlorine accidents and acute poisoning.

Certain products, such as polycarbonate and polyurethane, are also unacceptable because of the many toxic and cancer-causing raw materials involved in production, even though these final products do not contain chlorine compounds.

Even though it may be possible that any escape of material can ultimately be prevented, the present situation is still that these productions cause real and substantial problems and have a long way to go before all loops are closed.

4a.2 Chlorine unintentionally released to environment

Production processes which create chlorine containing products that are not intentionally meant to be released into the environment.

The major components of this group of products that will probably end their life in the environment are the volatile organo halogen compounds, like the halogenated solvents: chloromethanes, chloro- ethanes and chloroethenes. The vast majority of this production will ultimately evaporate into the atmosphere, at an estimated rate for Western Europe of 500,000 tonnes annually. The compounds play a key role in atmospheric chemistry, including smog formation, ozone depletion, and greenhouse effect. They also contribute to ground and surface water contamination and are found in food, especially diary products, as in the case of perchlorethylene used in dry cleaning shops.

- Methyl Chloride, used to makes silicones, methyl cellulose and agricultural chemicals.
- Methylene chloride (dichloromethane) used as cleaning agent and paint remover, as a propellant in aerosol cans, polyurethane foam and in organic synthesis of pharmaceuticals. The substance is also used for soil disinfection.
- Chloroform (trichloromethane), used to make HCFC-22 and as an anaesthetic
- Carbon tetrachloride (tetrachloromethane), used to make CFCs.

- Ethylene Dichloride (1,2 -Dichloroethane), used to make Vinyl Chloride Monomer (VCM) and PVC plastics.
- Vinyl Chloride Monomer, used in PVC production.
- Methyl chloroform (1,1,1,Trichloroethane) an important solvent used as cleaning or degreasing agent and as chemical intermediate.
- Trichloroethylene (1,1,2, trichloroethylene) used as a chemical intermediate.
- Perchlorethylene (1,1,2,2-tetrachloroethylene) the most important solvents in dry cleaning. Also used in metal cleaning and degreasing in the electronic industry, paint and adhesives industry, car production, plating industry and printing industry.

At present, the bulk of produced organohalogen solvents evaporate. Most of the residual part of the solvents becomes contaminated with (organic) compounds, not infrequently chemicals that can be harmful for man and environment. Depending upon the application, the concentrations may range from a few percent of 'dirt' in the solvent to a few percent of solvent in the air.

Major producers of chlorinated solvents in India include, Chemplast at Mettur, TN, DCW Ltd at Dhrangadra, Gujarat and Sahupuram, TN, Gujarat Alkalies and Chemical Ltd, Baroda, Gujarat and Modi Alkalies and Chemicals Ltd, Alwar, Rajasthan.

Chloro-fluro-carbons (CFC's)

A special category is formed by the chloro-fluro-carbons (CFCs). The manufacturing base for CFC's is the same as that for chlorinated solvents, and the two groups are associated with some similar environmental effects. They are applied as solvents, propellants in spray cans, blowing agents in foam plastic production and coolants in refrigerators and air conditioning.

The CFCs form a large family, every member of which has more or less severe capacities of ozone-depletion and greenhouse forcement. Ozone plays a major role in the chemistry of the earth's atmosphere, in particular restricting the amount of UV radiation reaching the surface of the earth. As a result of ozone depletion, levels of UV-B radiation reaching the planet surface will increase, and the effects may be profound. The damaging effects on plant life include DNA damage, alternations in growth and metabolism, general inability to photosynthesise, some crops reduced yield. In animals squarmous cell carcinoma and diseases of cornea; in fish various skin diseases; and in humans an increase in UB-B will inevitably increase levels of various skin cancers.

Some of the CFCs are subject to the Montreal Protocol that envisages a phase- out of several products and/or applications in a number of countries within the next one or two decades. Nevertheless, not all compounds are covered, and production will continue for some time and shift to other CFC's in parallel, for example HCFC's and HFC's. The efforts of their (still extensive) production, including the associated wastes, will remain with us for many years.

India's 1995 production of CFCs and HCFCs has been estimated at an annual 30,000 tonnes. The key producers are Chemplast, Gujarat Fluorochemicals, Mettur Chemicals, Navin Fluorine and Shwram Fibres [96, Vallette, 1995].

Perchlorethylene (Perc)

Over 90percent of all dry-cleaners use chlorine-based perchlorethylene to clean clothes. Some 3 million pounds of this highly toxic chemical is used annually by the industry in the US and Canada alone. Dry cleaners are the single largest users of perc, releasing massive emissions of the chemical into the environment. Dry cleaners also generate large amounts of perc-

contaminated waste which, in the US, are burnt in incinerators or cement kilns. The burning of this waste results in the formation of hundreds of deadly by-products including dioxins, furans and hexachlorobenzenes. Extensive ground water contamination has also been reported from the US. Workers are especially vulnerable, particularly in shops which use 'transfer' machines, in which perc-soaked clothes have to be manually transferred from the washing machine to the dryers. In Germany dry clearing shops are held liable for concentrations of perc found in the air in adjacent properties.

PVC

PVC production must also be included in this category. The primary production processes lead to significant emissions of organochlorines and its by-products. The chlorine bound in products will ultimately escape, either slowly in landfill or as by-products of incineration. The processes, products and environmental effects of PVC are discussed in detail in Section 3 of this report.

Production materials changing

Apart from PVC production most uses of these organochlorines is in decline in the north. Pressure has come from both regulatory authorities, consumers and workers, exposed to these mostly hazardous chemicals in the workplace, to find substitutes:

- degreasing operations are now being accomplished by aqueous solutions mechanical means or ultrasonic cleaning;
- chlorine-free methods are now being used by major manufacturers of cars, paints, electronic or other equipment;
- clothes cleaning by "wet cleaning", in specially designed machines using soap and water;
- CFCs in refrigerators are being replaced by refrigerating processes that use ammonia, hydrocarbons or other cooling methods; and now
- PVC products are being replaced with a variety of alternative materials.

4a.3 Chlorine intentionally released to environment

Production which delivers chlorine containing products meant to be released to the environment: Because of their importance in India, they are covered under a separate section.

4b Pesticides and POPs

Most of the chlorinated pesticides have been banned or restricted in use since the 1970s. However, the international community, through UNEP (United Nations Environmental Programme) has decided, as a follow-up to the UNCED (United Nations Commission on Environment and Development) "World Summit" in Rio in 1992, to ban globally a range of what are described as POPs, - Persistent Organic Pollutants. All these are organochlorines and most are pesticides. The priority list includes PCBs, dioxins and furans, aldrin, dieldrin and endrin, DDT, chlordane, hexachlorobenzene, mirex, toxaphene and heptachlor. Other compounds are recommended by PAN, Pesticide National Network, for example lindane (gamma HCH) and it's closely associated compound benzene hexachloride (BHC). Both organisations, UNEP and PAN, have priority lists of 12 popularly called the "Dirty Dozen".

The Intergovernmental Forum on Chemical Safety (IFCS) recently recommended that "UNEP and WHO should initiate immediate international action to protect . . .through measures which will reduce and/or eliminate production and subsequently the remaining use of those (POPs) that are intentionally produced." To achieve this, the IFCS called for the expeditious development of a global, legally binding treaty. Action on these recommendations is expected in early 1997.

4b.1 India's attempts to ban

India is one of the few countries still manufacturing, using and exporting many of these 12 Persistent Organic Pollutants plus other POPs such as pentachlorophenol, lindane and BHC. As such it has a key role to play in banning and phasing-out production. But its current role seems at best ambivalent and the situation remains confused. At least one researcher has concluded that "Measured by tonnage, approximately 70percent of all pesticides used on Indian farms are banned or severely restricted in the north, and identified by The World Health Organisation (WHO) as extremely toxic or hazardous." [97, Iyer, 1993]. According to an estimate, nearly 350,000 tonnes of DDT, 575,000 tonnes of HCH and 150,000 tonnes of organic phosphates have been used since 1985. [98, Hindu, 1991]

After seven years of review, the Government of India decided in 1993 to ban heptachlor and chlordane, two pesticides known to be "moderately hazardous based on their acute toxicity" [99, PAN, 1990]) and classified by the US EPA as "probable human carcinogens". The ban was short-lived, though. The industry promptly challenged the government notification on grounds that the decision was taken unilaterally. The government was forced to invite comments from the industry, although at the end of the 'consultation' it reiterated its earlier decision to ban the two pesticides. But that was two years later, in 1995, and to date, the official notification is not out.

Such long-drawn processes to phase out or ban even the mostly obviously hazardous POPs, are typical in India. A blanket ban is not even subject to discussion. "We should evaluate each case individually within our agroclimatic context," says S.C. Mathur of Pesticides Association of India. And decision makers in the government tend to agree.

So on a case by case study, the Government of India has managed to ban or phase out at least seven - campechlor, (toxaphene) chlordimeform, DBCP, pentachlorophenol and the three drins - of the "Dirty Dozen" pesticides (as listed by PAN).

4b.2 DDT and BHC

The Central Insecticide and Pesticides Board (CI&PB), which is the concerned regulating body in India, says that the pesticides are constantly reviewed by expert committees, who recommend bans or regulatory actions for their continued use. The final decision, however, is usually the result of a prolonged tug-of-war between various government departments.

Take the case of DDT and BHC. The use of DDT in agriculture was withdrawn in May 1989; its use was restricted to 10,000 tonnes/annum for the public health program, National Malaria Eradication Program. BHC, which accounts for 25 percent [100, Bhargava, 1995] of the pesticide market, is “the most widely used insecticide in agriculture because of its low cost” [101, GOI, 1986]. Both DDT and BHC are slotted for phase out in 1998. However, any attempt to phase out DDT or BHC from the health programme, in the absence of a “viable substitute” will be and is being staunchly opposed by the Ministry of Health and the Ministry of Chemicals and Fertilizer. A shift from DDT to Hoechst's Delta Metharin, a substitute currently being evaluated, would push up the Health Ministry's expenditure by five to six times [100, Bhargava, 1995].

The Ministry of Commerce, however, is keen on phasing out DDT and BHC, even from the health sector. “Exports are being affected because these pesticides are being re-exported to the USA and Germany in the form of residues in food grains and agriculture produce”, says Sanjay Sengupta, program officer at the Delhi-based NGO Voluntary Health Association of India (VHAI).

In this multiparty battle, the issue of environmental health has taken a back-seat because, according to a senior official at the CI&PB, “No hard evidence is available”, relating the presence of DDT residues to negative effects on human health.” The official, who spoke on condition of anonymity, said that DDT, which has high residual activity, is the best pesticide for combating “Kala Azar” a deadly disease peculiar to the eastern Indian states of Bihar and West Bengal. “You have an option; either you die out of Kala Azar today, or face whatever long-term effects that residues pose”, he said.

There's no denying the presence of residues, though [102, India_Today, 1989]. Citing an ICMR (Indian Council of Medical Research) 1993 study, a report in the Deccan Herald states that: “An analysis of 186 samples of infant formula collected from various places in India revealed the presence of DDT and HCH residues in 70-95percent of samples” [103, Hathi, 1994]. Two separate Expert Committee reports on DDT [104, GOI, 1985] and BHC [101, GOI, 1986] concede that pesticide residues have entered the food chain and contaminated the environment [103, Hathi, 1994]. Both reports hasten to add that there is no reason for worry yet because no cases of acute poisoning either by direct exposure or due to residue build-up have been reported. Interestingly, Section 26 of the Insecticide Act, which provides for each state to make pesticide poisoning a notifiable occurrence, has not been implemented to date [105, Dudani and Sengupta, 1991]. “That's because diagnosis is very difficult and our MBBS curriculum doesn't prepare doctors for diagnosing or reporting such incidents,” the CI&PB official says.

However, at least one estimate based on WHO figures reports that India accounts for one-third of the 5,000 acute pesticide poisoning cases that occur every year in the south [97, Iyer, 1993].

4b.3 Industry’s resistance

After the government's decision to restrict the use of DDT in 1989, production was solely vested with public sector Hindustan Insecticides Limited. BHC on the other hand is manufactured by at least 14 medium-to-large companies, including Calcutta-based Kanoria Chemicals and Industries Ltd and Mumbai company Tata Chemicals.

When the DDT phase-out was first proposed, government-owned Hindustan Insecticides supported by the Ministry of Chemicals and Fertilizers, argued that it would cripple the company which had expanded its capacity to 10,000 metric tonnes. It would seem that DDT is as much a cure for Hindustan Insecticides' illness as it is a pesticide to combat malaria.

But pressure from industry and the Chemicals Ministry notwithstanding, government sources say both pesticides are likely to be phased out by 1998. Already, the government has announced for BHC a 50 percent production curtailment by the end 1996, and a total phase out by March 1997, according to the Pesticides Association of India.

The Government is encouraging BHC manufacturers to shift to lindane (a chemical relative of BHC), another one of the Dirty Dozen pesticides identified by PAN. "Other countries may have banned (lindane) because of overreaction or low market potentiality", says the officer from CI&PB. According to him, lindane has no known negative side-effects and good insecticidal activity. "India can't afford to overreact. It's a choice between a few ppms of pesticide residue and starvation," he adds dramatically. Clearly this official is unaware of current scientific concern over hormonal dysfunctions being caused by DDT and lindane.

4b.4 Restricted but available

The restricted pesticides probably pose the gravest threat of all. Because they have already been "restricted" it is difficult to convince the government to totally ban them. The government thinks it has done enough. Meanwhile, the restricted pesticides continue to be available on the market, and to untrained end-users.

The pesticides are distributed through a network of 112,000 retail outlets, all of which have to submit periodical reports about sales and stocks as per the Insecticide Act's requirements. But government sources acknowledge that there is no control once the pesticide reaches the farmer. And it is common knowledge that requirements of the Insecticide Act are seldom complied with.

Aldrin, which CI&PB says is banned, is used by poachers in the Central Indian state of Madhya Pradesh to poison tigers and other endangered species to supply the illicit wildlife body parts trade, according to Ravishankar Kanoje, a forest ranger from Madhya Pradesh. BHC is illicitly used by vegetable distributors to give the vegetables a 'fresh look'.

4b.5 Expansion in old technology

The Indian pesticide industry has grown tremendously from 5,000 metric tonnes in the late 1950s to 70,000 metric tonnes per year of technical grade material. Production of technical grade material is dominated by large national and multinational firms. The formulation industry, which has a capacity of 140,000 metric tonnes, is evenly divided between a few large and about 500 small players [106, Lindstad, 1995].

Moreover, "India is keenly looking forward to an additional investment of $740 million" [107, Sharma, 1995]. Disturbingly, chlorine production for pesticides too is set to soar with new capacities slotted to come up in the next three years [108, Rao, 1996], and exports remain a viable option, having increased from Rs.640 million in 1989 to Rs. 2 billion in 1994.

The Pesticides Association of India reports that "significant breakthroughs have been achieved. Indian pesticide products are now being exported to USA, France, UK, USSR (sic) besides a host of countries of South America, Asia, Middle East, Africa and to Australia" [109, Mathur and Bahl, 1995].

In 1994, Indian companies exported Rs.2.74 million worth of BHC to Germany, Rs. 4.33 million worth of DDT to Germany, Singapore and the Netherlands, Rs. 102.18 million of lindane to France, Italy and Portugal. [109, Mathur and Bahl, 1995].

Even though the local industry is more than 40 years old, neither the multinationals nor the Indian companies have introduced state-of-the-art pesticide technology or new molecules. R&D by Indian companies is restricted to developing process technology. Indian companies can't afford to spend the $20 million per year required for new product R&D. "Expenses can only be recovered if finished product is sold all over the world. This requires efficient international marketing organisation operating in most industrialized countries" which Indian companies lack [110, UNIDO, 1988].

If the industry has been tardy in developing alternative pest control mechanisms, the government's performance too has not been spectacular. "Alternatives are not coming down from lab to land", says Sengupta of VHAI. Programs for Integrated Pest Management seem to be mere catch-phrases reserved for mention during parliament question hours.

4c Small Units / Large Estates in Gujarat

India has over 3 million small-scale units, and alhough they account for about 45percent of the industrial output, "it is estimated that the pollution generated is more than their share of production. This is an area where regulatory efforts have not been able to make any significant inroads. It is not merely the numbers, but the lack of enforcement. And yet the number of smaller enterprises is increasing at an annual rate of 8- 10percent." [111, Nyati, 1995]

The World Bank echoes these views, "While the capacity of the eight state control boards supported through Bank-financed projects to monitor and regulate large and medium-size industrial units in the highly polluting sector has improved, there is little enforcement in the small sector or in the area of toxic and hazardous wastes". However, "an expanded pollution abatement program for small-scale industrial units, building on the common effluent treatment plants and environmental extension program is already under way through Bank projects." [112, Cambridge, 1996]

In these units chlorine is used in pesticide formulation, the manufacture of pharmaceuticals, chlorinated paraffins, perfumery formulations and in a host of both inorganic and organic processes

4c.1 The Golden Corridor

The industrial belt, termed the "Golden Corridor, lies alongside the main north-south highway linking Mumbai to Ahmedabad. Here are some of the dirtiest industrial operations in Asia, grouped in estates in Nandesari, Vapi and Ankleshwar and elsewhere. Dye factories, textile, rubber, paint, pulp and paper manufacturers, pharmaceutical, engineering and chemical companies, small and medium sized units rub shoulders one after the other in a grid of streets. The characteristic yellow containers of chlorine gas lie haphazardly in unit forecourts.

Contaminated sludges and solid wastes are indiscriminately dumped by the banks of rivers or in convenient open areas at the edges of the estates. Brightly coloured dye effluent runs in open ditches past tea stalls in the main streets.

"A red dog laps up purple water from an open gutter, while a yellow cow ambles past. Dreams in Technicolor? No...just one of the many everyday scenes in Ankleshwar, Gujarat, Asia's largest chemical industry zone and possible one of the most polluted." [113, Iyer, 1995]

Tikku, aged 24, a contract labourer for the Gujarat Industrial Development Corporation (GIDC) earns Rs 35 a day; "This entire area (in Nandesari) belongs to the GIDC. All this multicoloured muck you see here comes from the factories, all over the estate", he said. "It is like this, tractors come with the waste from the factory and they just dump it, pile it layer upon layer here and over there, in the north side of the estate." He pointed to a row of assorted homes made of corrugated iron, wood and cardboard boxes.

Tikku commented that it was impossible to stay in the estate at night. "The factories emit more at night and the stench is oppressive, it hangs over the whole estate and you cannot get away from it - you cannot breath." He added, "Many people have breathing problems and our children are affected the most."

Kanubhai, a loader of wastes on tractors, earning Rs 15 per tonne, added his comments: "If I were to live for a hundred years, this area with its chemicals in the water and strong smelling gases have taken at least twenty years off my life. There are many health problems in this area

like TB, chest and breathing problems, it's a terrible life". (Interviews 8.4.96, translated from Gujarati)

Worker Exposure

Conditions within the chemical units are obviously worse. Chemical Engineer C.G. Pandya has surveyed the worker health and safety situation in both Vapi and Ankleshwar and identified a number of areas of concern [114, Pandya, 1992]:

- 50percent of chemical storage tanks were found to be in a bad or very bad condition with over 61percent of units surveyed having no scheduled maintenance system for storage tanks.
- Almost 80percent of workers were not using personal protective equipment.
- Alarm systems were only available in 18percent of units.
- Start-up and shut-down procedures were only written down in only 17percent of some units surveyed. There were shortages of qualified managerial and supervisory staff in 45percent of units.
- 68percent of units suffered from pollution. Pollution due to water contamination and odour is present in 80percent of units
- The effects of air pollution particularly on workers at present exposure levels include respiratory and irritation troubles in 77percent to 82percent of factories. Adverse effects on skin and eyes were noted in 86percent of units.

Workers are mostly employed on a casual basis through labour contractors. Thus employers have no liabilities to pay benefits, such as medical expenses or are provided with personal protective equipment. Wages are low. Morale is very low "because of the conditions they have to undergo simply to keep going. Excessive and continual exploitation by the combination of labour contractors and management (specifically of the casual and unskilled labourers interviewed) has brought down morale." [114, Pandya, 1992].

International Labour Organisation (ILO) statistics show that India experiences the third highest level of fatal accidents - about 25 deaths per thousand workers every year. It is not known how many of these fatalities are caused by exposure to pollution, fugitive emissions and handling of toxic material in industrial units. Nor is it clear how morbidity levels are affected by such exposure. And these are only the reported figures.

Greenpeace analysis: Nandesari, Ankleshwar, Vapi

Greenpeace sampled and analysed a number of open effluent discharges and solid wastes in Nandesari, Ankleshwar and Vapi.

Nandesari

In Nandesari we sampled a discharge running under a road and pouring into a deep gully where sludges were being dumped. It was tentatively identified as being a combined discharge from 3 plants, namely Bakul Chemicals, Parul Industries and Farmson Pharmaceutical. The main contaminant in the waste stream was DDT, in such concentrations that Greenpeace's sensitive analytical equipment was in danger of being damaged! A total of 15 individual organochlorines were identified, 8 of which were isomers of DDT or its derivatives. Supposedly manufacture of DDT has been restricted to government-owned Hindustan Insecticides.

The GIDC has installed a Common Effluent Treatment Plant (CETP) for wastes from both small units in the Nandesari estate and for large companies such as Indian Petrochemicals Ltd (IPCL) and Gujarat Alkalies and Chemicals Ltd (GACl) operating in the area. We visited the treatment plant and were offered samples collected by the technical staff and access to sampling treated effluent.

This treated effluent contained large quantities of the highly toxic, persistent chlorobenzenes. One such waste stream was simply identified as "mixed Nandesari", a second as mixed effluent from GACl, IPCL, Polychem, Diamines and Chemicals, Calico Polyester and Fibres and Indian Dyestuffs.

Even more revealing were the samples provided by the GIDC laboratory, which originated from specific plants, supposedly post-treatment, prior to discharge into the common channel and thence into the Narmada river. Of these, Indian Dyestuffs was discharging 1,3 -dichlorobenzene, 1,2,4- dichlorobenzene and 1,3,5-trichlorobenzene. Gujarat Petro-Synthese was discharging hexachloroethane and hexachloroethane and pentachlorocyclopropene. Transpek Industries were discharging 1,2,4 trichlorobenzene, hexachloroethane and hexachlorobutadiene.

The latter chemical is considered a useful indicator for the presence of dioxins and furans and is a known animal carcinogen. Very low doses via food can induce kidney and liver damage in animal experiments. It is included in the UK "red list" for priority control. None of these identified compounds have any place in the open environment.

Ankleshwar

Mono-, di- and trichlorobenzenes were also found in open effluent streams in Ankleshwar. These are all highly persistent and are frequently considered a high priority for elimination in the north.

Aldrich Chemicals belched a rather bilious yellow effluent into a channel adjacent to a public roadway. The principle contaminants found in this effluent were 2,6-dichlorobenzenamine and 2,4,5-trichlorobenzene - quite common intermediates in pharmaceutical manufacture.

Purnima Chemicals Ltd had spread a yellow dye on a patch of empty ground, presumably to dry. Workers were covered in it as they packed it into sacks. This dye contained di-, tri- and tetrachlorobenzenes. It is totally unacceptable to grossly expose the environment let alone humans to such chemicals.

Vapi

Vapi is home to Chemie-Organics; described by Greenpeace scientist, Dr David Santillo, as, "possibly the worst piece of chemical plant I have ever, and will ever, set eyes on." He was unable to sample what appeared to be the main effluent channel because there were too many workers queuing to wash themselves and their tools in it! However, a sample of sludge from an open ditch on-site revealed a host of highly toxic, persistent organochlorines: apart from the ubiquitous chlorobenzenes, the sludge also contained high levels of mono-, di- and trichlorobiphenyls (i.e PCBs), chlorinated terphenyls and hexachlorocyclohexane. The full list reads like a guide to the most dangerous organochlorines. Any responsible regulatory authority would shut down this plant immediately.

Protest in Ankleshwar

Environmental protest has been focused mostly on Ankleshwar, the largest and most obviously polluted estate. In May 1996, when Greenpeace took samples, Nandesari looked somewhat derelict and empty. The courts had recently "closed down" 26 industries because of water pollution by cutting off water and electricity. Workers were fearful about potential other closures. However, Ankleshwar, employing 70,000 people in over 1,200 companies bustled with activity.

At present all the effluents in the estate, along with effluent from the nearby Panoli estate and the expanding industrial area of Jaghadia are collected through an underground sewage system and dumped into open canals, or Amlakhadi, where it flows through farmland to the Narmada River, a distance of some 30 km.

Farmers have been protesting since the estate was opened in 1972. These canals were originally used to capture the flood waters of the Narmada and provide local farmers with a good water source for crops such as sugar-cane, vegetables and banana. Industrial effluent is turning the farmland to wasteland. During monsoon Amlakhadi overflows, submerging lands in polluted water. Fruit trees, which were once plentiful have been replaced by the ubiquitous and hardy weeds

Babubhai is head farmer of a village near Dhantura which has been severely affected by the overflow from the Amlakhadi channel. "We have been living with this stench (hydrogen sulphide) over our houses and crops for over 20 years," said Babuhai. "Our crops grow less and less each year, our children are less intelligent, slower and listless. The adults can feel the effects of these chemicals too. We feel constantly nauseous and dizzy and suffer skin problems on our hands and feet. This has to stop, it is affecting every part of our lives and we have been fighting it for the last ten years to no avail. Nobody listens and nobody seems to care. The industries are getting richer. They are robbing us of our lives and livelihoods." (Interview 9 April 1996).

However, a local group of activists, Manaviya Technology Forum, working with farmers have forced some change. In 1992-3 they stopped IPCL extracting groundwater which local people used. In November 1995 GIDC was made to stop construction of an effluent pipeline from its Vagra estate to the Narmada estuary. In January 1996 GIDC was forced to stop construction of a pipeline from its Jaghadia estate to release more effluent into the Narmada. [115, CSE, 1996]

Now the GIDC has agreed to build a long sea-outfall to pipe all effluent from these estates underground to the sea. NEERI, The National Environmental Engineering Research Institute, is looking at the potential impact of these wastes on the marine ecosystem and identifying the best place to end the pipeline.

Local farmer, Jayesh Patel is very sceptical about these plans, suspecting that the 50 crore of rupees it will take to construct the pipeline will be hard to find. Local fishermen express concern over impact of effluent on already declining fish stocks.

Waste Management plans

The Ankleshwar Industries Association is putting a brave face on its pollution problems. They have plans to expand the local hospital to include recruitment of specialists in occupational health, burns treatment and respiratory illness. Schools are being built and already the Rotary Club has planted over 3.0 lakh of trees, a minimum of 1 lakh per year until the year 2000. Mostly they seem to be planted as a greenbelt screen, separating managerial housing from the ugly site of industrial units.

The National Productivity Council (NPC) has estimated that some 27,000 tonnes of hazardous waste per year (TPA) is generated by some 186 industrial units in various estates in the area. In addition some 18,600 TPA of hazardous waste is expected to be generated from the planned treatment of industrial wastewater [116, NPC, 1995].

UNIDO (United Nations Industry Development Organisation) through US Aid has given a grant to build a solid waste incinerator to deal with waste from all nearby estates. Non-hazardous waste will be dumped in a dead quarry; identified as suitable by the NPC. But this report is not necessarily accurate.

According to the Ankleshwar Industries Association, Ankleshwar alone creates 60,000 TPA of solid waste. The Government of Gujarat has agreed to develop the abandoned stone quarry for solid waste disposal. A sum of 30 crores is required to develop the site including an incinerator and other facilities [117, AIA, 1996].

However, in their previous evaluation [116, NPC, 1995]., the NPC showed reticence about this site:

"The site is having very fragile land and deep excavations. Therefore it is suggested to level and install impermeable liners such as a strata of clayey soil. The site is about 40km away from the sources of hazardous waste generation and also not connected with asphalted road. Therefore, and internal traffic linkage has to be established before development of secure landfill".

It is common knowledge that so-called secure landfills are rarely secure and impermeable liners will, however well engineered, in time become permeable and leach toxic materials into groundwater. Incinerators will produce highly hazardous by-products such as dioxin from burning chlorinated wastes and always create toxic ash to add to landfill and further test so-called secure facilities.

Pride of place in this waste management scheme is the newly constructed Common Effluent Treatment Plant (CETP). The first of 4 planned CETPs, this will treat 1 million litres of effluent per day. It has cost Rs 5.5 crores; Rs 3.3 crores through a World Bank loan routed via The Industrial Development Bank of India. However, only 79 (out of 1,200) units will contribute effluent from the most visible polluting sector, the dye industry and also some from 'fine chemical' plants.

The President of the Small and Medium Chemical Manufacturers Association, Raju Shroff, is bullish about CETPs, "One of the most effective tools industry and government have created to improve the environment while keeping small units open." [118, Chemical_Week, 1995]

But even the Deputy Chief Engineer of GIDC, K.B.Bhagat remains sceptical, "But even today the effluents of the industry are acidic. In such as situation even existence of CETP, which is largely biological treatment, would be useless as the bacteria would be killed by the acidic effluents, and regeneration of the bacteria will take another three months. Thus CETP is not the solution. After setting up the CETP, the situation will be worse. People are only buying time in recommending CETP. If you look at the operation of CETPs, you will see that are not successful anywhere. Pollution control has to be at the unit level." [115, CSE, 1996]

4c.2 Dispelling the myth of the Common Effluent Treatment Plants

Greenpeace is convinced that CETPs will not lower the toxic burden on the community of Ankleshwar, local farmers and fishermen or the Narmada estuary. Like long-sea outfalls, dedicated landfill and incinerators, they serve only to shift and hide the problem.

The rapid and, in many cases, poorly planned growth in the chemical manufacturing sector in India has generated a waste handling problem of enormous magnitude, which, in turn, has led to widespread environmental pollution and serious threats to human health. Tyagi [119, Tyagi, 1991] recognised the scale of the existing problem (then estimated at around 1 million small-scale, water-polluting industrial units) and predicted the situation would become even more difficult as the chemical industry, particularly that centred around key industrial development areas, continued to expand.

Most industrial processes generate a contaminated wastewater stream. The larger, more modern plants, operating on the international markets, have addressed treatment of wastewater and other waste streams at the plant design stage (although the range of chemical parameters considered probably remains very limited). This is not the case for the majority of the medium to smaller sized industrial units, for which individual waste treatment systems are not considered to be an economically viable proposition.

As a consequence, most of the effluent and solid waste streams generated within the chemical industry sector receive little or no treatment prior to discharge. On the industrial estates of Ankleshwar and Vapi there is a simple system of open roadside ditches, designed to carry mixed effluent to pumping stations or directly to a river system for discharge.

CETPs are currently being promoted as the long-term solution to the problem of contaminated wastewater disposal. SEE WORLD BANK QUOTE.

Where waste treatment plants are in operation, either at isolated industrial units or CETPs, they are commonly designed to address a very limited number of physical (pH, conductivity, suspended solids), biological (BOD, COD, coliform counts) and simple chemical (nutrients, oil and grease, phenols, some heavy metals) parameters [120, Hadjivassilis and al, 1994].

Since complete waste characterisation is not a requirement for compliance monitoring with existing emission standards, many components of the waste streams, most significantly the persistent organic compounds, are simply being overlooked. Wastewater which meets the requirements of existing, very limited, pollution control legislation is therefore considered acceptable for discharge to surface waters, despite the fact that it may contain high concentrations of, for example, persistent organochlorine chemicals. Such was the case for two of the five treated effluent streams monitored by the GIDC effluent quality monitoring laboratory near Baroda, dealing with wastes from Nandesari and adjacent plants, in which di- and trichlorobenzenes were particularly abundant but would normally remain undetected.

In addition, while CETPs may well address part of the problem relating to high loading of surface waters with degradable organic material, BOD, solids and nutrients, these plants are fundamentally incapable of degrading or detoxifying the wide range of heavy metal and persistent organic contaminants which are also present.

At best they can achieve a redistribution of these contaminants from the liquid to the solid sludge phase, reducing the immediate loading to surface waters but creating an additional contaminated waste stream which must be disposed of.

Greenpeace analysis and discussion of CETP's

Some less persistent organic compounds (eg. 2,4-dichlorophenol) can be degraded by microbiological processes. However, to achieve acceptable and reproducible degradation of such compounds, specific process designs are generally required, including an inoculum of micro-organisms acclimated to survive with, and metabolise, the waste compounds in question [121, Fulthorpe and Allan, 1995], [82, Gonzalez, 1996]. Many organisms appear to

be capable of degrading chlorinated long-chain aliphatic compounds, but fewer strains can metabolise chlorinated aromatics [122, Mohn and Tiedje, 1992]. Complex and expensive plant, and long effluent residence times, are often required in order to achieve removal to an acceptable standard [123, Tunay and al, 1994]. The upflow anaerobic sludge blanket plant is one such system [80, Duff and al, 1995].

These systems are frequently subject to stimulation or inhibition as a result of changes in the flow rate and composition of wastewaters [87, Limbert and al, 1995], [124, Jin and Battacharya, 1996], or of changes in environmental variables such as process temperature and temperature of the inflowing effluent [125, Liss and Allan, 1992]. Activated sludge digestion appears to be particularly sensitive to changes in flow rate resulting from batch production processes [126, McAllister and al, 1993], [127, Rebhun and Galil, 1994].

Shock loading with higher concentrations of particular compounds can perturb biodegradation processes in a manner which may be highly complex and difficult to predict [128, Lu and Tsar, 1993, [Torslov, 1994 #131], [85, Strotmann, 1995]. In addition, it should be noted that systems designed specifically to treat chemical wastes are frequently less efficient at achieving conventional biological treatment to reduce BOD, suspended solids and related variables.

In contrast to specific bioreactor systems, a typical Common Effluent Treatment Plant would receive wastewaters from a wider range of industrial processes. This, by definition, would result in more complex and variable effluent composition and supply rates, rendering specific process design practically impossible [129, Eckenfelder and Musterman, 1994]. The mixing of highly complex waste streams, some of which may be hot and contain chemically active compounds, can result in the synthesis of new compounds in a largely unpredictable manner [130, Johnston, Stringer, 1996].

In addition, a large proportion of higher chlorinated organic compounds are highly resistant to biodegradation [131, Gruttner and al, 1994a], while metal contamination can never be destroyed through such processes, other than to scavenge them from the dissolved to the particulate fraction [132, Gruttner and al, 1994b]. As a result, many of the most toxic and persistent components of chemical waste streams may simply pass through the CETP unmodified.

Englande [133, Englande, 1994] emphasises the fact that there are no simple "off the shelf" solutions available for dealing with complex waste streams arising from diverse chemical manufacturing processes.

Biological treatment plants may be effective in addressing certain limited physical, chemical and biological parameters, but can form only part of an overall waste management strategy. Waste reduction strategies must form a central part of waste management programme, be it on the scale of a single process or plant, or of an industrial development region as a whole.

Brenner et al. [134, Brenner and etal, 1994]and Belkin et al. [135, Belkin and al, 1994], while discussing the strategy for the Ramat Hovav industrial complex in Israel, recognised the need to trace recalcitrant waste streams back to their origins and begin to address them at source. This necessarily involves detailed chemical characterisation of all the waste streams produced, leading to a re-evaluation of the raw materials and processes employed, in order to identify mechanisms for the reduction of use and release of persistent, toxic pollutants [136, Unden, 1994]. Ultimately it may be necessary to reformulate products in order to meet the long-term goal of elimination of priority pollutants at source.

Big is beautiful?

Thus policies pursued by government and industry to install CETPs in small units serves only as a cosmetic device to allay public concerns. More worrisome is the ill- informed activism of environmental lawyers who are campaigning for closure of plant throughout India until CETPs are installed. The World Bank, by using India's precious currency reserves to service loans financing CETPs, shoulders more blame for this erroneous policy, since with their resource and access to expert opinion one would have expected recognition that this pollution control technology would not restrict entry of many hazardous chemicals into the environment.

The GIDC has now abandoned any further development of small chemical industries. A reported Rs 25,000 to Rs 30,000 crores of industrial investment is scheduled for Gujarat.

Although environmental activists have restricted construction to only four plants in Jaghadia until the site is connected to the long-sea outfall being planned to dispose of wastes from Ankleshwar and Panoli, many more large-scale toxic industries are intended for Gujarat. In Bharuch alone three copper smelting units are either under construction or planned. Cement factories and a huge petrochemical complex threaten a fragile marine sanctuary near Jamnagar. Back in Jaghadia some plants are already operating without full environmental clearance.

No doubt modern plant design and engineering will produce better working condition. But even the latest end-of pipe technologies will not eradicate and destroy toxic wastes. They will be concentrated in sludges from treatment plant and then dumped in landfills or incinerated, serving to hide rather than eliminate toxic chemicals, particularly persistent organic compounds.

Section 5 PVC

"The question is not whether to phase-out PVC but how PVC should be phased out"
Swedish Environment Minister, Anna Lindh, November 1995.

Introduction

Of all the plastics that now impact our everyday lives, PVC - PolyVinyl Chloride or 'Vinyl' - is the most dangerous for the environment and human health. It is dangerous at all stages of its life cycle; during primary production processes, when it is used, and in the processes of disposal at the end of its useful life.

Where other plastics, such as Polystyrene (PS), Polyurethane (PUR), Polycarbonate (PC) and Acrylonitrile-butadiene-styrene (ABS) are also environmentally unacceptable, none can match PVC for its creation of hazardous organochlorine compounds during manufacture and disposal or the range of toxic additives needed to make it a viable product.

Exposure to the chemicals used in PVC manufacture can cause cancers, liver tumours ands birth defects. Throughout is life-cycle PVC generates the most toxic chemical by-product known, dioxin. Some additives used to make PVC 'soft are not only toxic but have been recently listed as chemicals that are thought to interfere with hormonal systems thus interfering with fertility and possibly threatening the future of humanity.

While many countries in the north are taking steps towards the eventual phase-out of PVC, India, aided and abetted by licensing agreements with chemical giants in Europe, the USA and Japan, is expanding its PVC industry.

Table 5.1 Existing commodity plastic production facilities in India

Producers	Licenser	mta
Reliance Industries Ltd	BFG160	
Finolex Plastics	Hoechst	130
Indian Petrochemicals Corp. Ltd	BFG	55
Shriram Vinyl & Chem Industries	Sinetsu	33
Chemplast	BFG	50
DCW	Kureha	40
NOCIL	Shell	25

Source: Indian Chemical Markets Conference proceedings, March 1995

Table 5.2 New Capacities and expansion plans

Company	Addition	Date
Reliance Industries	440	1998
Finolex Pipes	150	1997
DCW	150	1996
Chemplast	30	1996

Source Indian Chemical Markets Conference proceedings, March 1995

At the heart of these dangers lies chlorine. PVC is comprised of 57percent chlorine and 43percent hydrocarbons. While other uses of chlorine, in pulp and paper bleaching, the formulation of pesticides and the production of chlorinated solvents, is declining in the north because of environmental pressure, PVC has become the ultimate sink for chlorine. 30percent of annual world chlorine production of about 40 million tonnes now goes into making PVC.

After Polyethylene (PE), PVC is now the second most common plastic worldwide. But in India the PVC industry now claims the largest market share (28percent) among the commodity plastics. While markets in Europe and the USA are relatively static, the PVC industry in India estimates its growth at an annual 15percent [137, Dhuldhoya, 1996].

Brief history of PVC

The history of PVC is entwined with some of the 20th century's key chemical giants. Though vinyl chloride was first discovered in 1835, the first commercial plant only went on stream in 1936, by a US company that later became Union Carbide. In the same year, B.F Goodrich established DEHP (di-2-ethylhexyl phthalate) as the best plasticiser. During the 1930's, Nazi Germany expanded chlorine production in order to make the country independent of imported cotton in case of war. After years of experimenting with stabilisers, lubricants, and softeners, it was found that fibres could be made from PVC, along with a myriad of other products. Post 1945 the manufacture of PVC has accelerated from a mere 0.4 million tonnes per year to the present 22 million.

In India PVC production started in 1961. Chemplast (Chemicals and Plastics Industries Limited) at Mettur in Tamil Nadu started in 1967, with technology from B.F. Goodrich. The first integrated PVC complex was set up by NOCIL (National Organic Chemical Industries Limited) in Thane, near Munbai in 1968, with help from BASF (Germany). Reliance Industries built the first world-scale plant (160,000 tonnes) in 1991, with technology from B. F. Goodrich. Indian's PVC industry was founded by the heirs of 1930's US and European companies: Chemplast , Reliance and IPCL with technology from B. F. Goodrich (USA); NOCIL with technology from BASF (Germany); Finolex with technology from Hoechst (Germany).

Uses of PVC

Table 5.3 Indian PVC usage

Sector:	percent
PVC Construction	38
Agriculture	16
Communication/Power	14
Consumer	10
Footwear	10
Packaging	7
Transportation	3
Medical	2

Sources: NOCIL March 1996

PVC is used to make a broad range of products which are so diverse that it is difficult to imagine it as being a single material. In only a few decades, PVC has invaded every part of our lives. It is used in packaging - for mineral water to soft drinks bottles, boxes, cling film; in consumer articles - credit cards and toys. It is used in our homes; in construction - window frames, doors, walls, pipes and gutters; around the home for flooring, wallpaper, blinds and shower curtains; in the office for furniture, folders, pens; in the car industry - especially as underseal. It is used in hospitals for medical disposables such as gloves and blood bags; in cable and wire insulation, for irrigation pipes. It is used for garden furniture and imitation leather. Everyday more and more people in India are wearing PVC chappals (shoes). It is everywhere and is responsible for displacing traditional more ecologically compatible materials such as wood, leather and natural textiles, ceramics and glass and other plastics.

5a The manufacture of PVC

Table 5.4 The five key stages in the manufacture of PVC

1. The basic materials, chlorine and ethylene are produced from salt and petroleum respectively.

2. Ethylene and chlorine or hydrogen chloride (HCl) are combined either in direct chlorination or an oxychlorination process to produce ethylene dichloride (EDC). The oxychlorination route is the most commonly adopted world-wide.

3. EDC is "cracked" to produce Vinyl Chloride Monomer (VCM) and HCl. The HCl is recycled back into the oxychlorination process.

4. VCM resin is polymerised into polyvinyl chloride (PVC).
Two alternative processing routes are available, so called mass-polymerisation and the suspension or emulsion process.

5. PVC is processed into formulations for specific end-uses through the addition of various additives which confer particular properties to the plastic.

Source: ECOTEC Research and Consulting Ltd et al

Stages 2-4 are usually carried out in large integrated chemical facilities for example in India of Reliance, Chemplast, DCW, NOCIL, Finolex and others. The final processing into products is done by a host of medium and small-scale companies.

The growing globalisation of the Indian chemical industry has meant that more and more raw materials such as EDC are bought on the world market. Since the greatest cost of manufacturing PVC is energy (about 70percent), which is an expensive and undependable commodity in India, EDC is now commonly shipped from the Gulf of Mexico, USA or the Arabian Gulf, where energy prices are much lower than in India.

Sea transportation poses potential environmental threats to the marine ecosystem. Dedicated chemical ports are being built in India especially along the Mahrashtran and Gujarat coasts to handle these shipments and also the import and export of other chemicals. Further environmental threat comes from the risk of spillages during unloading operations and accidents on India's highways.

5a.1 EDC and VCM production processes

EDC and VCM are highly dangerous organochlorines, threatening workers and the immediate community surrounding PVC facilities and the wider environment.

EDC is highly toxic and easily absorbed by the skin. It is poisonous by ingestion, inhalation and intravenous routes. Vapours produce irritation of the respiratory tract, conjunctivitis, corneal clouding, equilibrium disturbances, narcosis and abdominal cramps [138, Sax, 1987]. It causes cancer and birth defects; damages the liver kidneys and other organs; it can cause internal haemorrhaging and blood clots. It is also highly flammable; the vapour can explode, generating hydrogen chloride and phosgene gas (two highly toxic gases that can cause Bhopal-like disasters).

VCM, made from EDC, is also dangerous. 95percent of its production is used to make PVC. It is a human brain carcinogen. It causes severe irritation to the skin, eyes and mucus membrane. It causes skin burns by rapid evaporation and consequent freezing. In high concentrations, it acts as an anaesthetic. Chronic exposure has shown liver injury and circulatory and bone changes in the finger tips reported in workers handling unpolymerised materials. It is a dangerous fire hazard when exposed to heat flame or oxidisers. Large fires of VCM are practically inextinguishable [138, Sax, 1987].

Worker Exposure to VCM

"Care should be taken to prevent accidental over-exposure to vinyl chloride during PVC production through the user of proper respiratory protection. Workers should also avoid exposure to polyvinyl chloride dust generated during grinding, drying or cleaning operations. Medical surveillance under the Occupational Safety and Health Standard (OSHA, set in the USA in 1974) required annual examinations of workers exposed to vinyl chloride, looking for liver enzymes. Assessment of lung function is also recommended." [139, Sullivan and Krieger, 1992].

From 1927 until 1970, there was extensive exposure to unreacted vinyl chloride monomer in chemical plants in the USA producing PVC resin. In the early years of production, air levels of vinyl chloride routinely exceeded 1000 ppm, at times resulting in very high exposure to workers, who often became overcome by narcotic concentrations (15,000-20,000ppm). In the mid 1970's, the toxicity and carcinogenity of VCM monomer was recognised after the discovery of several cases of angiosarcoma (a rare liver cancer), in workers at a US PVC production plant.

Exposure to VCM is also associated with male reproductive disturbance including lowered androgen levels (sperm count) and impotence. Oedema during pregnancy has been reported in occupationally exposed women. Statistically significant elevation of congenital abnormalities has been reported in communities close to VCM/PVC plants [140, Johnston, 1993]. Subacute liver injury with fibrosis has also occurred with heavy exposure.

In the USA over the past 15 years, worker exposure to vinyl chloride has been reduced significantly, from 100-200ppm in early 1970's to less than 5ppm since the promulgation of OSHA. The risk of developing angiosarcoma, and possibly other malignancies (brain tumours, leukaemia), remains uncertain. This is particularly true for workers who were first exposed prior to 1970 [141, Sullivan and Krieger, 1992].

According to the Indian Factories Act 1948, amendments 1987, section 41 F, Threshold Limit Values (TLV's) in the Indian work environment are 5ppm (time average 8 hours) and 10ppm (weighted concentration) [142, Pandey and Kanhere, 1993].

But TLV's are based on 'risk assessment' procedures, which are not scientifically rigorous. As we can see from Table 3.5, at different times higher exposure levels were deemed "safe". Quite often TLVs change due to pressure from workers and unions. Are we now sure that 5ppm is "safe"? And safe from what, cancers, fertility disruption, lowered sperm count?

Table 5.5 VCM Threshold Limit Values

Date	ppm	Scientific data which provoked change
1962	500ppm	affects central nervous system
1971	200ppm	affects bones, liver and kidney
1975	25ppm	instigated as interim by UK
1978	5ppm	causes cancer of liver

Section 41C of the Indian Factories Act asks the occupier of the industry involving any hazardous process to maintain accounts and up-to-date health records of the workers in the factory who are exposed to any chemical, toxic or any other harmful substances. [142, Pandey and Kanhere, 1993]. But it is not known if workers are examined on a regular basis for diseases attributed to PVC manufacture. Indeed ethylene dichloride (EDC) is not listed in the List of TLVs according to the Factory Act, and neither is DEHP [142, Pandey and Kanhere, 1993].

5a.2 PVC processing

Plastic material processing requires that the VCM resin be converted to a soft, malleable state through the application of heat or pressure followed by mechanical constriction to the desired form and cooling.

Generally the large Indian PVC companies claim to have adopted international standards of operation, but the large number of small and middle sized companies where PVC is moulded, injected extruded and calendered to make a myriad of PVC objects, are mostly unregulated and are notorious for ignoring safety precautions and concerns for workers or the environment. This category excludes the illegal fly-by-night operators in the back-streets and jhuggis of Indian metropolitan areas who steal electricity from the grid to turn plastic including PVC throw-aways into down-cycled products.

Worker exposure during PVC processing

In PVC processing workers may be exposed to the following health hazards: vapours and dusts containing chemical intermediates; polymers, and additives during loading, mixing pelletizing and maintenance operations; dry mixing and pelletizing operations may generate high concentrations of airborne dusts or combustible plastic materials, which along with human health hazards, also presents an explosion hazard.

Plastic processing equipment operates using high temperature and pressures, and needs to be equipped with proper guards and safety rails to avoid serious burns, amputations and crush injuries. Plastic grinding may generate polymer dust, resulting in inhalation and a possible combustion hazard. The overheating of plastic materials during processing, cleaning and maintenance operations may expose workers to the thermal decomposition products of the polymer materials. Finishing operations (including the use of paints, adhesives and solvents) may expose workers to a variety of their chemical compounds. In addition, cutting of plastics may result in repetitive motion injuries, such as tendonitis and sprains. [139, Sullivan and Krieger, 1992].

While combustion hazards are primarily respiratory irritants (HCl, aldehydes), significant pulmonary injury from nitrogen oxides and phosgene as well as system poisoning from carbon dioxide and cyanides may occur.

There is evidence that exposure to PVC dust during grinding and other fabrication in some workers accompanied by a slight reduction in pulmonary function. Exposure to plasticisers and additives such as DEHP or chlorinated paraffins (Section 5b.2), essential in the manufacture of soft PVC, can also create chronic health problems. The long term health effects of exposure to combustion products of plastics is unknown.

Thermal decomposition products of PVC, created during melting processes, include hydrochloric acid and phosgene, both respiratory irritants. Other thermal decomposition products are dioxins

and furans, the most toxic organochlorine by-products known. A sure way to create dioxins is to heat PVC scrap at low temperatures. See Box 3.1 Dioxin.

Problems with worker insecurity

The law of the land has so far tried to uphold the Right to Life of the common citizen in accordance with Article 21 of the Indian Constitution. However, its scope to protect the right of a common worker to live and work in a clean, healthy and an occupational disease free environment has not received the Courts attention. [143, HMS-ILO, 1996]. Monitoring and ensuring occupational safety in India is inextricably linked with the workers insecurity about employment: "Workers fear detection of occupational disease because of risk of losing their jobs. Workers are often themselves unwilling to go in for check-ups and claim compensation for occupational diseases due to this insecurity of employment. Employers have played on these fears. They have often encouraged compensation attitude whereby instead of removing hazards, the emphasis shifts to hazard allowance" [143, HMS-ILO, 1996].

5a.3 Waste from VCM/EDC production

It is impossible to produce organochlorines, including EDC and VCM without producing residues and wastes. These are routinely discharged to water, vented to air, dumped in landfill or incinerated. All these pathways expose communities and the environment to an unacceptable loading of hazardous chemicals.

Not all wastes generated by PVC production escape from the factory. Through a process called chlorolysis, approximately a third of the waste residues are turned into new chlorinated products. Many are familiar: perchlorethylene, is the common dry cleaning fluid and a suspected carcinogen; carbon tetrachloride used as a degreasing agent and is an ozone depleting chemical and known human carcinogen. Other by-products of PVC production include pesticides, the infamous ozone depleting CFC's and cleaning fluids. As is true of all chlorine-containing products these new applications spread more toxic emissions into our soil water and air, and thereby into our bodies.

The remaining wastes are impossible to contain in manufacture - no matter how sophisticated and well run a plant is. The risk of spills, accidents and bad on-site management only intensifies the problem.

PVC production facilities have been termed 'dioxin factories' (Box 3.1 Dioxin) by ecologists for very good reasons. The thermal cracking of EDC can lead to substantial waste of spent copper catalyst, a known catalyst in the production of dioxin. It has been estimated that up to 80percent of the dioxins found in sediments in an area of the Rhine River in the Netherlands have been caused by VCM production. A staggering 340-640 grammes of dioxin equivalents were reported recently by UK company ICI to have been deposited in rivers in the North of England, mostly from by-production of chlorinated solvents. Parts per trillion of dioxin are considered worrisome.

Greenpeace investigation has shown high concentrations of dioxin in the waste stream of PVC facilities in the Gulf States of the USA [144, Costner, 1995]. Recently Greenpeace Italy found high levels of dioxin in sediments and shell fish caught in historic Venice lagoon. The authorities have stopped discharges from the PVC plant concerned, while they conduct further investigations. All these incidents take place in countries with tight monitoring standards.

Greenpeace analysis of Chemplast Sanmar

Effluent streams of Chemplast Sanmar's facility at Mettur Dam, Tamil Nadu were sampled during Greenpeace's survey of some polluting industrial units in India in May 1996. This

company manufactures PVC, chlorine gas (by both mercury cell and diaphragm processes) and a range of chlorinated solvents. It also manufacturers CFC's, mostly banned in the north (Section 4a.2)

Four discharges were identified as waste streams originating from units 2 and 3 of Chemplast. The first of these was an open channel running beneath the main access road to the plants. Samples were taken of both the wastewater and the underlying sediments. The other three waste streams sampled were carried in closed pipes through the village and discharged together into an open river channel. Samples were taken of each of the wastewaters, and of the sediment below the combined discharge point.

No organochlorines were detectable in the wastewater contained in the channel running beneath the road. In contrast, the sediment sampled at this location showed clear evidence of previous or perhaps continued intermittent discharge of organochlorines. Of particular significance were 1,2-dichlorobenzene, 1,2,3-trichlorobenzene, and substantial levels of tetra-, penta- and hexachlorobutadiene (HCBD).

Little information is available regarding the toxicity of tetra- and pentachlorobutadiene, whereas HCBD has been fairly well characterised. It is likely that, as with the chlorinated phenols and benzenes, toxicity may decline with decreasing degree of chlorination, HCBD being the most toxic.

HCBD is a fairly common contaminant produced as a by-product in a number of industrial processes involving chlorine chemistry. It is included on the UK Red List of priority pollutants for control [145, Agg and Zabel, 1990], on account of its acute and chronic toxicity and persistence in the environment. It is a known animal carcinogen and a suspected carcinogen in humans (listed by the US EPA). If ingested, HCBD concentrates in the kidney, interferes with fundamental processes of cell respiration and can, as a result of conjugation with other compounds in the body, react with DNA resulting in cell death or the development of tumours [145, Agg and Zabel, 1990]. Short and longer-term exposure to very low doses via food, induced kidney and liver damage in laboratory animals, with juveniles more at risk than adults.

HCBD is often considered to be a useful indicator for the presence of chlorinated dioxins and furans [144, Costner, 1995]. The presence of this and related compounds in an open channel near the centre of a village is clearly cause for concern.

Similar compounds were isolated from two of the three piped effluents, discharging to a common river channel some distance from the road. The first, a pink, turbid wastewater stream (identified above as containing 1.09 mg/l mercury), contained significant levels of hexachloroethane, PCBD and HCBD. The second, again unidentified in terms of source, contained very high levels of TCBD, PCBD and HCBD as well as of relatively volatile organochlorines, including tetrachlorobutene, hexachlorobutene and pentachlorobutene. Of 18 substance isolated, 13 were reliably identified; all 13 were organochlorine compounds. Such discharges may arise as waste streams from oxychlorination reactions, or perhaps from secondary chlorination of plastic resins.

The third of these wastewater streams contained no organochlorine compounds.

Analysis of the sediment obtained below the combined discharge revealed accumulation of hexachloroethane, TCBD, PCBD and HCBD from the wastewater streams. Hexachlorobenzene (HCB), another common by-product of oxychlorination, was also

detectable in the sediment although none was detected in any of the discharges sampled. Of 9 compounds isolated from the sediment, 8 were identified, all of which were organochlorines.

Incinerating and Landfilling VCM/EDC Wastes

Wastes from EDC/VCM production not vented to air or discharged to water are routinely sent to dedicated high temperature incinerators. Indeed, as regulatory authorities in the north clamp down on visible waste streams, more and more wastes are diverted to incinerators, where the problem remains 'hidden' behind factory walls and diluted with huge quantities of air before being spewed into the environment. Incineration does not destroy wastes, it merely changes solids to gases and simplifies disposal problems by reducing the volume of waste.

The countries of Western Europe once thought the practice of burning EDC/VCM wastes too dangerous on land and special ships were built to burn the waste at sea, far from populated coasts. Scientific evidence of damage to marine organisms and public outcry soon stopped ocean incineration worldwide and now these wastes are burned on land. Incinerator technology has, apparently improved! However in Germany, the most dangerous, that is the most heavily chlorinated wastes, are considered too dangerous for incineration and instead are stored in perpetuity in salt mines.

The chlorine content of PVC makes it completely unsuitable for incineration.

- However sophisticated, high temperature incinerators still emit large quantities of metals, dioxins and other organochlorines to air and, through contaminated ash, to soil and water. The incineration of 1kg of PVC produces enough dioxin (TEQ) to initiate cancer in 50,000 laboratory animals. [146, Thorpe, 1992].
- Whenever chlorine is burned, HCl (hydrogen chloride) is formed. This poisonous, corrosive substance must be removed from flue gases to avoid serious environmental pollution. This entails high capital investment, efficient monitoring and sizeable amounts of energy.
- Incineration also produces concentrated toxic ash which has to be landfilled. Even in well managed landfills, with the best membrane liners, leachate (the liquid seeping through the body of the landfill) will always escape, thus polluting aquifers and groundwater.

5a.4 Regulating the PVC Industry

In India the need to control waste emissions from PVC production hardly seems to make the agenda of the CPCB, despite the pollution problems outline above.

The PVC industry is not specifically identified by the Ministry of Environment and Forests as one of the 18 Highly Polluting Industry Sectors, unless it comes under the catch-all Petrochemicals industry (see Box 6.1).

The PVC industry is not listed as one of the 62 polluting industries in Schedule 1 of the Environmental Protection rules 1986 or in any of the other 5 Schedules of the Government Pollution Control Acts. [147, CPCB, 1996]

As an industry discharging water, it does require consent to discharge under the Water (Prevention and Control of Pollution Act 1974). However, none of the chemicals tested for include mention of the complex array of organochlorines or organochlorine by-products created by PVC production.

Many organochlorines are listed as some of the 434 Hazardous and Toxic Chemicals in part 2 of the Schedule of The Manufacturer Storage and Import of Hazardous Chemical Rules 1989, but

this act is designed to identify major accident hazards, prevent such accidents and provide training to persons "working on the site with the information, training and equipment including antidotes necessary to ensure their safety", These rules are not intended to regulate routine emissions of such chemical's to the wider environment.

The PVC industry finally surfaces as part of a "List of Projects Requiring Environment Clearance from the Central Government". This schedule includes all projects that must seek clearance under the Environment Impact Assessment Notification, 1994. It is unlikely that all but a fraction of the complex array of hazardous organochlorines created by the industry are both tightly restricted in future operations or monitored.

Indeed India does not even possess the capability of routinely monitoring dioxin, despite the growing number of 'dioxin factories'. It's like having a nuclear industry without any means of measuring radiation.

The most toxic dioxin compound, 2,3,7,8-TCDD is listed as one of the named chemicals under The Manufacture, Storage and Import of Hazardous Chemical Rules (1989). But threshold quantity is placed at 1kg, an enormous amount in view of the toxicity of this substance. Even trying to set a threshold for dioxin indicates basic misunderstanding of its presence in small amounts as a by-product. Since there is no means of testing for it in India, any mention at all is purely academic

5b From Resin to Products.

PVC is unique among plastics for reason other than its contains chlorine. PVC cannot be used without a range of additives, which often comprise as such as 60-70percent of the total volume. A range of over 4,000 additives exist to create different PVC products, although about 150 are in common use. In its normal state PVC is hard and brittle so a range of heavy metals and chemicals, mostly toxic, are used to make the material soft and pliable. Other additives add colour, or make it flame resistant or protect the material from bacteria or fungal growth.

Table 5.6 Composition of Common PVC products (percent)

Product	PVC	Assorted additives	Plasticisers	Stabilsers
Cable coat	42	36	21	1
Films	32	51	16	2
Flooring	28	56	14	1
Pipes	93	5	-	2
Window frames	78	12	-	4

Source: ECOTEC research and Consulting Ltd.UK 1995

5b.1 The Additives

The main additives and their uses are as follows:

1. Pigments

Used to colour the end product. The types of dyes used include inorganic metal-based compounds, and organic pigments which comprise a variety of azo, nitro and carbonyl dyes some of which are synthesised using chlorinated intermediates.

The azo dyes achieved notoriety recently in India, when Germany, because of their toxicity, refused to import textiles from India that used azo dyes. The textile industry is looking into alternatives, but is the PVC industry?

2. Lubricants

A variety of lubricants are used in PVC manufacturer. The most common types are the fatty acids, chlorinated paraffins, fatty acid esters and metal soaps. In Western Europe in 1985, about 25percent of all lubricants used in PVC processing contained toxic metals such as lead and cadmium, which have well known neurological effects on animals.

3. Flame retardants

Fire resistance of PVC is improved by the addition of certain metal oxides. The use of such metal oxides has come under attack because they may increase the toxicity of fire gases. The commonest fire retardants and smoke repressors added to PVC include antimony trioxide, phosphorous esters, chlorinated paraffin's and aluminium hydroxide, boron compounds and molybenum trioxide. A large percentage of fire retardents manufactured are used in the PC industry. All these compounds are human poisons, boron compounds in particular. Some are also carcinogens and mutagenic [138, Sax, 1987].

4. Foaming agents

The most important blowing agents for PVC foam are air, CO_2 and N_2. Other agents used include trichloroethylene and CFC's. These materials tend to escape as fugitive emissions from the end product. Although data are scarce, azodicarbonamide appears to be an important agent at addition levels of between 0.3percent-1percent. Chemicals given off by the foam include carbon dioxide and ammonia and a variety of nitro generated solid residues remain in the PVC foam. The toxicological significance of these residues remains largely unknown.

5. Biocides

Biocides are added to soft PVC to prevent the biodegradation of plasticisers by micro-organisms. Landfill lines, carpets cable covers and shower curtains are treated to prevent fungal degradation and insect attack.

6. Plasticisers

These, as their name implies, make the plastic flexible and reduce the hardness and brittleness. Flexible PVC is used for a wide range of applications such as packaging, cables, flexible irrigation pipes, toys etc. The most common plasticisers used are a group of complex chemicals called phthalates. The most common of these is di-2- ethylhexyl-phthalate - known by its abbreviation, DEHP.

5b.2 Plasticisers, phthalates and their effects on human health

Phthalates persist in anaerobic (without oxygen) conditions and are found throughout the environment. The German EPA has estimated that 1600 tonnes of DEHP are released in Germany annually into the atmosphere, of which 50percent is from processing. 5percent of another phthalate, DBP, also used as a plasticiser in PVC, is also lost to the atmosphere in Germany. [148, Claus. F., 1991]

Over three million tonnes of DEHP are produced world-wide, of which at least 95percent produced was used in 1993 as an additive for PVC plastic, for example in floorings, wallpaper, cables, toys, packaging and fashion goods [149, Greenpeace, 1996].

The migration of DEHP and similar plasticisers from cling film into foods, especially fatty foods such as dairy products, has led many manufacturers to offer alternatives such as non-PVC film. In Austria, DEHP is banned in packaging that has direct contact with food. In Switzerland, the use of DEHP is banned in toys designed for children under three. DEHP is on the priority list of environmentally toxic substances in the Netherlands and the US. DEHP has to be labelled "environmentally hazardous" in the European Union.

PVC flooring releases particularly high concentrations of plasticisers and contributes to the "sick building syndrome" reported in modern western office blocks. In Sweden 24 cases of sick building syndrome were studied. In 8 of them PVC floorings were involved and a range of additives within the PVC were identified.

Phthalate plasticisers have also been found to leach from blood storage bags, where it readily migrates into the blood. This has been recognised for over 25 years [150, Blass, 1993], [151, Van Dooren, 1991], [152, Lundbert and al, 1992] and can lead to very high blood levels in infants given transfusions, and in patients on kidney dialysis. They have even been found to leach out of hose pipes [153, DoE, 1991].

Not only is DEHP a known animal carcinogen and a suspected human carcinogen, but, along with other phthalates it is an endocrine disrupter.

The PVC threat to human fertility

Scientific research has in recent years focused on phthalates because, like many organochlorines, they act as endocrine disrupters. That is, they can mimic natural hormones and interfere with fertility, can create rare cancers of the genitals and other reproductive abnormalities. The unborn, and babies, through their mothers milk are particularly susceptible.

In 1994, the German EPA stated "We are of the opinion that the use of DEHP plasticiser much be considerably restricted. No time should be wasted as the current environmental concentrations in compartments with release potential are already so high that they may cause environmental damage". [154, GermanEPA, 1994],

Scientists and media in India are aware of this problem. In an article in "The Week" magazine, August 25th 1996, scientists and researchers told how "the number of men with low sperm count is definitely going up in India". Dr Paveen Kini, an andrologist in Bangalore is sure about one thing: "The problem will be worse if we do not stop these chemicals. Look at what happened to the white rhino and the grey whales. They are on the verge of extinction because of these man made chemicals". The article lists some of the suspected chemicals and their sources. "Human exposure to phthalates is believed to be from foods which have absorbed the chemical from their packaging or from manufacturing processes".

Plasticisers in India

Other phthalate plasticisers used in India include:

- Di-Octyl-Phthalate (DOP), used widely for manufacturing leather cloth, footwear, rain coats, cable coating, hoses, flexible pipes, packaging, medical grade disposables etc. DOP is also used for manufacturing plastisols (frequently used for making children's toys), paints, nitro-cellulose lacquers, plasticised PVC film, sheets for wrappings, floorings, tiles and gaskets.
- Di-Iso-Octyl Phthalate (DIOP), used as general purpose plasticiser like DOP.
- Di-Iso-Decyl Phthalate (DIDP), used especially for cabling and wire insulation compounds and shower curtains.
- Di-Butyl Phthalate (DBP), has major application in the shoes industry and can also be used as a plasticiser in rubber, cellulose, and many other resins. It is used in Poly Vinyl Acetate paints where it promotes film formulation and for manufacturing adhesives and emulsions.
- Di-Ethyl Phthalate (DEP), used as a fixative agent for perfumes in cosmetics, shampoos, ointments, adhesives and insect repellents.

All these compounds are now under scientific scrutiny for their role in creating human hormone dysfunctions.

Other additives used in PVC, such as organotins, cadmium, lead and small quantities of alkaliphenols are also suspected of interfering with hormones. But perhaps the most potent disrupters are the dioxins, created throughout the life cycle of PVC.

Table 5.7 Key plasticiser manufacturers in India

Company	Region in tonnes	Capacity in tonnes	Production percent	Market Share percent
Indian Organic Chemicals Ltd	Maharastra	10,000	3,076	30.6
Ganesh Benzoplast Ltd	Bombay	7,200	3,697	25.3
IVP Ltd	Bihar	1,500	1,268	11.1
Amines & Plasticizers Ltd	Maharashtra	4,050	3,281	10.9
Krishna Plastochem Ltd	?new	1,200	630	7.4
Thirumalai Company ltd	Tamil Nadu	na	547	6.0
Pearl Polymers	New Delhi	na	na	3.4
Chika Ltd	na	na	na	3.3
Nodipon Ltd	Maharashtra	800	114	2

Source: Economic Intelligence Service, January 1996

Chlorinated Paraffins

Chlorinated paraffins are used in PVC applications as a plasticiser, mould lubricant and flame retardant. Production is high in India, reaching about 100,000 tonnes annually, using a staggering 10percent of chlorine produced. Over 90percent of production is used by the PVC processing industry.

It is well known that certain types of chlorinated paraffin's are extremely toxic for aquatic organisms. Until recently these complex chemicals were very difficult to detect in the environment. Advances in analytic techniques by the German EPA led Greenpeace Germany in 1995 to analyse a whole range of substances including fish, porpoises, dairy products, meat and milk from cows and humans. The results were alarming. These chemicals were being found throughout the eco-system at levels corresponding to those of mostly banned organochlorines such as DDT, PCBs and the pesticide toxaphene (campechlor).

Presented with this evidence, the chief German producer, Hoechst, immediately announced that they would stop production of one type of chlorinated paraffins by the end of 1995 and the rest by 1998 in both their German and Brazilian plants. A European-wide ban is currently being discussed by the European Commission. Hoechst production of these chemicals was a mere 18,000 tonnes, compared to India's 100,000 tonnes.

In India, there has been no debate on this issue and chlorinated paraffins continue to be sold over the counter to an unknown number of PVC processors throughout the nation.

5c Phasing out PVC

Faced with all the various environmental problems of PVC, in November 1995, The Swedish Parliament adopted the advice of a preparatory committee;

"The Committee's opinion is that it is possible to make an overall assessment of today's PVC in all its parts from chlorine manufacture to waste. It is the Committee's opinion that such an overall assessment shows that PVC cannot be part of an eco-cycle society. Today's plasticised PVC, as well as rigid PVC with environmentally harmful additives, should therefore be phased-out. The phase-out should begin speedily."

In September 1996, The Environment Committee of the Danish Parliament mandated the government; "to get rid of the unwanted environmental consequences of using PVC." Measures include, phasing out use of lead, organotins and phthalates; decreasing the amount of PVC going to incinerators. The Danish EPA must discuss with retailers how to increase the market for PVC-free products, including identifying PVC by labelling. Other measures such as taxes to reduce the use of PVC are being considered. The Environment Minister stated that, "the aim of getting rid of environmental problems connected with use of PVC must certainly lead to a reduced use of PVC."

But these problems are not yet discussed in India, partly because consumption of plastics at 1.7kg (1993/4) per capita is still very low compared to Europe and North America. However, demand forecasts predict expansion to >3.0 kg by the end of the century. Over double present consumption but less than "many of the developing countries of south-east Asia." [155, Nanavaty, 1995]

Kamal P Nanavaty, senior vice-president of Reliance Industries, points out that "India is the world's largest producer of milk, butter, tea, sugar, ground nuts and a few other dairy and agricultural products. Packaging of agricultural produce, milk, dairy products, meat, fish, vegetables, fruits and various inputs that go into this core sector of the economy would provide substantial opportunities to plastics during this decade."

Just as we have seen with the expansion of the pulp and paper industry, the massive investment, often in technology and expertise from abroad, means that the PVC industry has to continually find new markets; mould rather than serve demand. As the north has started to reject packaging, India is expected to increase its consumption.

5c.1 Recycling in India

The plastics industry in India is proud of its recycling record. It doesn't want to admit that creating new markets for plastics will lead to waste disposal problems.

Sound ecological principles of recycling waste have always had a instinctive place in Indian society. But it is impossible to apply these to products whose disposal will always create problems. An army of children is ready to pick through municipal or roadside garbage dumps, or sit in dark 'jhuggi's' sifting through mounds of throw-away consumer plastics, some imported from the north. Out of a population of 940 million, between 44 and 100 million are working children [156, Spaeth, 1996]. In badly ventilated workspaces plastics are shredded and compressed into patties and, after addition of dyes extruded and chopped into pellets for making further products.

PVC like any other thermoplastic can, in theory be recycled. Complex machinery can identify the chlorine content and separate it from other plastics. In India this is done by "feel" and

experience. Often the "float" method is used. The polyolefins (HDPE, LDPE and PP) have a lower density than water and will float. PVC, other plastics, wet paper etc., whose densities are far greater than water, will sink.

But PVC, as we have seen is not a single material and many of its constituents are highly toxic additives. So how can it be recycled?

We put this question to Kamal P Nanavaty of Reliance Industries. Taking hold of a large bag, he opened it like a conjuror, and with a beaming smile pulled out a string of beads. " Any colour so long as it black as Henry Ford once said. And it can be moulded into any shape you want: a foot long generic mould, suitcases, toys.. a bicycle pedal.."

True recycling has two goals; to reduce the amount of new (or virgin) materials and therefore pressure on infinite resources and to reduce the amount of waste generated by society.

PVC can rarely be recycled into its original product.

Down-cycling products

The best that can be done with PVC is down-cycling, never, as with glass or paper recycling to the same product. And, at best, polymers can be only down-cycled twice before the polymers lose strength. Thus only temporarily delaying the process of disposal and hardly interrupting the stream of virgin plastics on to the market..

Thanks to cheap labour, these operations keep some of these plastics off the streets and also provide cheap PR for the polymer companies. "Its better to have children sorting through plastics than having them standing about on the streets causing trouble", proudly proclaims a Reliance executive.

Material recycling of plastics in the north has been mostly abandoned in favour of "chemical and energy recovery"; euphemisms for incineration. The costs of collection, sorting and reprocessing are greater than the price of virgin polymers. It is only economic in India because ragpickers in the slums of the big cities and particularly Mumbai come cheap and plentiful.

Recycling creates dioxin

Products that are solely made of plastics - packaging, pens etc. including PVC - can be temporarily down-cycled into products. But when PVC is used extensively with other materials to make more valuable goods - "white goods" (refrigerators, washing machines etc.), cabling, batteries and underseal in automobile manufacture for example - recycling becomes problematic.

Metals used in these products such as copper, lead and steel are expensive and re-usable and can therefore be recovered by smelting processes. However, secondary smelting facilities, which receive PVC as residues in automobiles, on cabling, electronic equipment and batteries even after they have been broken down for scrap and organic materials largely removed, have been identified by the US EPA as a major dioxin source [144, Costner, 1995].

Consequently, northern manufacturers such as Mercedes Benz, Volkswagen, Philips and Electrolux have been looking at ways to replace PVC in their products. As an interim measure, they have been examining ways of modular construction so that problem parts can be readily removed at the end of a product's life so as not to contaminate the precious metals. One of the world's biggest appliance manufacturers, AEG in Germany, have stopped using PVC in their products. They now market totally PVC-free cables, vacuum cleaners, ovens, washing machines, etc. Other major companies such as Siemens have similar policies.

5c.2 Waste in the end

However ingenious the use made of plastics in downcycling operations, ultimately India is facing a future plastics waste crisis. Despite recycling, some communities have already reacted and attempted to limit the flow of plastics into their eco-sphere. For example, The State Government of Himachal Pradesh has proposed a taxation of 30percent on plastic bags to drive them out of waste streams.

But it is difficult to see how effective community decisions can be on the consumption patterns of the middle classes. These are the areas of growth which the plastics, and particular the PVC industry wishes to exploit.

"There have been dramatic changes in the demography and socio- economic hierarchy in our country in the last three decades. Coupled with urbanisation, this has resulted in (the) massive middle class having substantially enhanced purchasing power. This section of the population has exerted a very strong influence on the socio-cultural ethos, day-to-day lifestyles and living standards thereby generating demands for newer products many of which are made from plastics...By the year 2000 close to 80percent (800 million) of India's population can be classified as a middle class market with a huge potential in urban and rural areas. These markets encompass household items of daily consumption, consumer durables and home appliances, footwear, furnitures and furnishings, transportation, packaging and medicare products. Today worldwide consumption of these segments (plastic products) is 6.2 million tonnes. In India the consumption is 142,000 tonnes which is expected to reach 245,000 by the year 2000." [137, Dhuldhoya, 1996]

Much of this material will end up in landfills, which however well designed will always leach its contents into streams, rivers and groundwater. PVC materials add a further toxic danger.

PVC in landfills

For every tonne of PVC burned. 0.9 tonnes of waste salts are created. Because these are contaminated with heavy metals or whatever additives there were in PVC products, the salt must be disposed of, usually in landfill.

Recent research in the UK by the British Geological Survey (BGS) showed that, "volatile carcinogenic compounds such as vinyl chloride and benzene migrating from landfill sites can build up in soils in levels close to or above safety limits." Vinyl chloride levels of up to 10ppmv measures in the soil gas and up to 24 ppmv in vent gas. [157, ENDS, 1994]. As we have seen, worker exposure to vinyl chloride In India has been set at a limit of 5ppm.

When PVC products are landfilled many of its additives, especially plasticisers, can be released either by the activities of micro-organisms or by the direct action of corrosive liquids in the landfill. Tests have shown that toxic stabilisers (cadmium/barium) can be leached from plasticised PVC in landfills. These heavy metals can be absorbed by plants.

"In landfills rigid PVC has proved very resistant to biodegradation. However, flexible PVC may lose some of its content by migration into other materials or by biological action in the upper layers of landfill. Flexible PVC in landfill dumps will slowly lose its plasticiser content to biological action. Heat stabilisers and other additives are also likely to leach. Continued use of PVC may increase levels of phthalates in the environment to more alarming proportion. The problems are more complex in putting incineration residues into landfills. The ash contains heavy metals and leaching is likely," [92, MIT, 1993].

Municipal Waste Incinerators (MWIs)

The problem of dioxin and other organochlorine emissions from municipal waste incinerators (MWIs) is linked to the presence and amounts of PVC in the wastestream. So far this is a problem in northern societies, but if the PVC industry is set to expand substantially in India, then there will be increasing pressure to incinerate the huge volumes of short-life PVC packaging and throw-away goods containing PVC, that the industry wishes to market.

Several reports have shown a direct link between the chlorine content of MWIs and dioxin formation. PVC and (usually) bio- wastes are the two main sources of chlorine. In northern countries with a good garbage separation system like The Netherlands has, PVC remains the only major source of chlorine and therefore dioxin. This was shown in a study commissioned by The Netherlands Environment Ministry (University of Leiden, 1993)

Halonen et al [158, Halonen, Tarhanen, 1993] showed that fuel with a higher chlorine content increased amounts of dioxin produced. Also Wagner and Green [159, Wagner and Green, 1993] made similar conclusions, " We find several statistically significant relationships between HCl (a surrogate for PVC in the waste) and the emission of a number of chlorinated organic compounds".. Any precautionary approach would keep PVC out of municipal incinerator waste-streams.

But the issue of PVC in incinerators is not just about dioxins. As we have seen with dedicated PVC waste incinerators, increasing the amount of PVC in the feedstock of an incinerator can also cause an increase in the amount of HCL and a largely unidentified quantity of volatile chlorinated and non-chlorinated materials. Elevated levels of lead and cadmium have been found in the vicinity of a MWI [160, Bach et al, 1992]. The plasticiser di-n-butyl phthalate (DBP) has beeen found in incinerator emissions; apparently a proportion of it is able to pass through the incinerator unchanged [161, Nishikawa and et al, 1992].

Medical Waste

Recently in India controversy arose when the Supreme Court directed the Government to install incinerators in all hospitals in Delhi with over 50 beds. This was in response to infection waste being routinely found by roadsides and in municipal waste dumps.

Environmental environmental groups argued successfully to the courts and to hospital authorities that this was an unnecessary, expensive and dangerous route to take.

The US EPA has identified medical waste incinerators as the largest known source of dioxins in the USA. PVC is the main source of chlorine in medical waste incinerators; used in packaging, gloves, infusion bags, disposable syringes, tubing, bedpans, trays and numerous other applications. Figures from the USA show that municipal waste consists of 0.5percent PVC whereas medical waste from hospitals is 9.4percent PVC and 3.8percent other plastics [162, Thornton and al, 1995]. Industry estimates that medical applications account for 2percent of total PVC production in India. [137, Dhuldhoya, 1996]

Instead of opting for a potentially hazardous catch-all solution, hospitals have been recommended to clearly analyse and separate their waste streams and take appropriate action with each segment. Re- usable and durable products should replace disposables. Cost effective technologies such as autoclaving should be installed as an alternative to incineration for many materials.

Above all, PVC products must be substituted. In addition to the incineration problem with PVC, there are additional concerns with plasticiser migration from blood bags already discussed in Section 5c.2. A number of hospitals in Germany, Austria and Denmark were found by NGOs researching the issue, to have substituted PVC products by non-PVC products; including

materials made of glass, metal rubber and less dangerous plastics such as PP and PE. The products included examination gloves, aprons, mattress covers, diapers, disposable syringes, wound plasters and dressing and packaging. In some hospitals, non-PVC infusion equipment, tubing, stopcocks, probes, catheters, collecting bags and breathing masks were also being used.

In May 1996, The Supreme Court changed its March decision. Instead of making it compulsory for hospitals to order incinerators, the Court took into account the environmental aspects of waste management, and ordered the CPCB to make standards not merely for incinerators (previously there had been none), but also for alternative medical waste technologies. The Court affirmed that hospitals are not obliged to install incinerators as their only disposal method, but may use other technologies. It said that any technology used must be environmentally friendly and in order to ensure this, the CPCB must be the monitoring agency [163, Agarwal and Chaturvedi, 1996].

5c.3 Stemming the flow

There are several policy tools that government could use to stem this flow of unnecessary and potentially hazardous products. These are outlined in full in Section 6 but how they could apply specifically to the PVC industry could be as follows:

Extended Producer Responsibility

Follow the example of the German Ordinance on the Avoidance of Packaging Waste (Verpackungsverordnung) of December 1991 which made manufacturers and distributors responsible for the packaging they create. Its goals were to reduce packaging waste requiring disposal and to develop sound material use practices. Industry was required to take back materials and either/reuse or recycle them, independent of the public waste management system.

Product charges

Impose differential taxes on materials to change consumer behaviour. Belgium proposed a higher "eco-taxes" on PVC bottles. Even though the law was not adopted, the threat was enough to drive mineral water bottlers into sounder environmental substitutes.

The same device can be applied to the growing market for PVC in the agriculture sector in India. To avoid leaching of additives into precious water supplies and the problem of disposal, the government could tax the uses of PVC in irrigation pipes and mulching, for example. This would encourage farmers to use more environmentally sound "transition materials" such as PP or HDPE and also make traditional materials more competitive.

The government does not yet face the plastic waste crisis of the north but wise measures at this point can prevent an unnecessary situation occurring.

5c.4 PVC in Buildings

"In the building sector, use of plastics is quite limited in India. These are mostly confined to construction activities undertaken in the metros and large cities in the form of water distribution and drainage pipes, conduits, storage tanks and to a limited extent use of profiles for windows. Demand for these, as well as other plastic building products, are growing in the urban centres and are simultaneously penetrating into the semi- urban areas." [155, Nanavaty, 1995]

Long-life applications of PVC have different environmental problems than short-life and "soft" products. Rigid products such as pipes and windows tend to use less additives and are therefore easier to recycle. Since they are used within the fabric of a building or externally, they have less impact on consumer health.

However, they belong to the same life-cycle of hazardous production processes and disposal and therefore are under threat from environmentally conscious regulatory authorities and those in the construction industry.

The majority of states and regional capitals in Austria have adopted policies to avoid using PVC in municipal buildings. Over 200 communities in Germany, including Berlin and the current capital city, Bonn have passed resolutions, either banning or restricting usage of PVC. Concerns in these communities, as well as others in Norway and Sweden, have focused on the role of PVC when exposed to fires in buildings.

PVC and fire

The widespread use of PVC products in buildings in the north, in floorings, wallpapers, shower curtains, window frames and electrical equipment including cabling and wire insulation - ensures that house and building fires will involve PVC products.

If this happens, an acrid smoke and dangerous organochlorine emissions, such as dioxin will be generated. A smoke containing hydrogen chloride (HCl) is readily formed with chlorine present and this combines with moisture (for example in the lungs) to form hydrochloric acid, which can cause serious burns to people, as well as considerable material damage. PVC need not actually burn for this to occur; in fact its chlorine content and flame-retardant additives may actually prevent ignition. Some of the worst fires have involved smouldering rather than burning PVC products. PVC decomposition products can lead to injury and death.

The HCl given off during fires reacts with the many additives present in PVC, creating even greater volumes of toxic fumes. In addition, heavy metals contained in PVC stabilisers will be released and this is specially dangerous in the case of cadmium.

One of the best documented cases of the role of PVC in fires is that of the notorious Beverley Hills Supper Club fire in the USA in 1977. During the fire PVC wiring decomposed forming a "wispy grey-white smoke" with no visible flames. An employee at the entertainment centre described how her fingernail polish reacted with the smoke eating through her fingernails. She developed second-degree burns wherever the smoke touched her.

By the time the flames became visible and the alarm was raised it was too late. Those present began to leave rapidly, but whoever came in contact with the smoke fell to the ground.

A total of 161 people died without any direct involvement with the flames, before any wood started burning, and before carbon dioxide reached dangerous levels. Many survivors suffered severe respiratory injuries. The PVC industry was forced to pay compensation to victims or their families.

There have been many fires like this since 1977. Most recently in April 1996, there was a fire at Germany's second largest airport in Dusseldorf. 18 people were killed by toxic fumes, made worse by the use of PVC cabling. Analyses by Dusseldorf's environment authority indicated that large areas of the airport have been contaminated by dioxins and furans. According to fire experts building materials such as PVC and various sealants are the cause of the contamination. The estimated costs for the clean up of the airport is USD 250 million over a time-frame of three years.

- In June 1995, a PVC market selling PVC products in Jwalapuri in West Delhi, was destroyed by an "out of control" fire. The result was a suspended black cloud of smoke over the area for several hours and which blocked out the light. Fire-fighters on the front-line of stopping the spread of the blaze suffered respiratory problems. Subsequent investigation found "excessive carbon monoxide, chlorine and vinyl chloride" at the fire site. [164, ET, 1995] The resident's of the area filed a public interest petition (PIL) in the High Court to uphold the Municipal Corporation's ban of PVC trade in the area. The court ruled "the citizens of this country have a fundamental right to breath fresh air, unpolluted by noxious gases. It is the duty of the government to ensure protection of right to breathe fresh and unpolluted air." Wherever the market is established, it will threaten both the community around it and the community at large.
- The previous year five persons died and 500 were hospitalised by a fire in a residential colony in Delhi caused by junk dealer burning PVC bags as fuel to recover metal from scrap [165, ET, 1994].The material used a fuel was found to contain heavy metals such as lead, cadmium, zinc , selenium, chromium and also cyanide as arsenic.

Manufacturers in the north have developed substitutes for products that are on the front-line of potential fires. Internorm in Austria have developed non-PVC windows, various companies in Germany now sell non-PVC cabling and wires. In high risk fire situations such as underground transport systems, for example the London Underground and the Channel Tunnel between the UK and France, non-PVC cabling has been installed; also in nuclear submarines.

Yet in India, PVC giant Finolex take out full page colour advertisements in magazines and co-opt the services of well known architects to praise their range of PVC cables. The Power and Telecommunication sector uses mainly PVC for sheathing of power cables, electrical and telecom conduits, flexible wires and control cables - a total of 69,000 tonnes annually or 14percent of total PVC production [137, Dhuldhoya, 1996].

38 percent of PVC production in India is used in construction. If the PVC industry is not stopped, the percentage and amount will substantially increase in the coming years. "As India moves ahead with the process of liberalisation, the building and construction sector will see a major growth as a result of construction of plants, dams, high-rise buildings etc. Not to mention the tremendous scope for housing for the masses" [137, Dhuldhoya, 1996].

Alternatives to PVC in buildings

The following chart gives an overview of the main substitution materials for the most frequent PVC applications in buildings. All of these products are effective substitutes for PVC.

Table 5.8 Alternatives to PVC in construction applications

PVC Product	Substitute material	Drawbacks of PVC compared to substitutes
Windows	wood (pine, larch, fir, spruce, beech, sal)	Because brittle at low temperatures; warping and discoloration may occur under sunlight
Flooring	ceramic tiles, wood,, linoleum, rubber, stoneware tiles, cork, hemp	plasticiser evaporation; no moisure permeability; not repairable after damage; discoloration
Walls	brickwork, pebble dash, wood, gypsum, plasterboard	temperature variations may cause material to come off; aesthetics; room climate.
Wallpaper	paper wallpaper with protective coating on acrylate base, ceramic tiles	plasticiser evaporation; aesthetic appeal
Facades, curtain walls	plaster, wood	poor durability, aesthetic appeal
Facades, curtain walls	plaster, wood	poor durability, aesthetic appeal.
Roll joints and hand rails	wood, metal	plasticiser evaporation.
Furniture	wood, metal	not repairable, plasticiser evaporation eg in artificial leather.
Blinds, shutters	wood, textiles	not as durable - PVC shutters usually turn brittle after 15 years.
Weather/draught strips for doors and windows	rubber	poor durability because PVC turns brittle and insulating characteristics disappear.
Sewage pipes	concrete, earthenware, polyethylene	more marked abrasion.
Sanitary installations, eg pipes and pipe coatings	steel, cast iron, copper, polyethylene, stoneware	increased abrasion, lower stability than steel/cast iron, limited section lengths; lower elasticity than other plastics
Electrical installations	plastics	heavy dioxin formation in the case of fire
Roof sheeting	plastics, bitumen sheeting	heavy dioxin formation in the case of fire
Construction product packaging	reusable packaging, cardboard, wood, other plastics	disposal problems.

Source: Greenpeace Austria

Note that PVC is not the wonder material that its industry claims; poor durability, tendency to brittleness, more marked abrasion are some of the characteristics of this so-called "long-life" material.

The Plumbers Union in Chicago, USA have opposed the use of PVC piping for a number of reasons, including the potential fire hazards mentioned above. They state, " our members are at further risk, particularly in hot weather, from the ingestion of PVC fibers through open pores.

Some experience discomfort from itching, others break out in rashes and still others experience more serious problems. It can't be said too often - polyvinyl chloride is a known carcinogen." On a technical note they added," plastic piping systems experience a much greater degree of expansion and contraction than do metal piping systems... This will result in costly leaks". They also mention the danger of plastic pipes being chewed by rodents. [166, Plumbers_Union, 1992].

Two of the largest construction companies in Sweden announced in May 1996 that they are starting to phase-out PVC. "There are alternatives to PVC, for example plastics that are not chlorinated. PVC can be substituted by completely different materials, such as tiles, ceramics and wood" says Invar Andersson at JM company. " I don't think anyone in the construction business today believes there is a future for PVC", says SIAB company's environmental director, Eva Mansson (press release, May 1996)

Economic instruments

Such as differential taxes would help drive construction companies into using more environmentally compatible products than PVC. These would achieve results quicker than tightening the end-of-pipe pollution control regime, which is difficult, time-consuming and expensive to manage. It is also open to abuses such as corruption and non-compliance.

Economic instruments can be levied at once, at point of sale, and would quickly change levels of emissions by rapidly changing the market and sales of PVC materials.

Extended Producer Responsibility

Especially with regard to long-life products, Extended Producer Responsibility would be appropriate. This is already in operation in Germany with cars . Germany, The Netherlands, Sweden, Japan, Austria, UK, Switzerland and France are also pursuing EPR policies for electronic products.

Both these tools are discussed in full in Section 6.

5c.5 Materials choice

If the external costs of producing PVC were taken into account, then, no doubt it would fare badly with traditional materials. This would mean adding the energy costs, pollution clean-up, regulation and environmental and health damage being done to workers and the community into the price.

Traditional materials, such as stone, wood, bamboo, mud, ceramics, glass are nearly always more suitable and environmentally sound than plastics. But modern building design often needs light-weight materials.

We make no apology for quoting examples of alternatives above from prosperous northern countries, where the socio-economic circumstances are so different from India's. They have had to live for longer with the consequences of a well-entrenched chlorine industry and are beginning to make systematic attempts to rid themselves of the problem. India is, as yet making no attempt to regulate or limit the onslaught of this menace from the north. We question whether, even taking into account the potential environmental damage, India has the political will to stop going down this development route. its certainly not too late.

However, many of the examples of substitutes chosen above are from resource-rich countries in the north. Sweden, for example, is rich in wood, iron and energy. Some of India's resources such as forests are sadly depleted and it is inevitable, with growing middle class prosperity, that plastics use will greatly increase.

Also we share the desire to improve the material circumstances of the poor in India and this means a pair of plastic chappals at an affordable price rather than expensive leather, or a cheap plastic rain-sheet during monsoon for slum dwellers, where tin is not an economic option. However, PVC is not the answer and there are other polymers that can supply basic services without the same environmental burden.

Life-cycle Analysis (LCAs)

Most authoritative "Life-cycle Analyses" (LCAs) or "eco-balances" compare PVC unfavourably with other materials. The Tellus Institute, an independent US research organisation, found that environmental impacts associated with the PVC life-cycle are more severe than those associated with any other packaging material. PVC's total environmental impact was 4.7 time worse than PET and 8 times worse than any other plastic. [167, Ackerman and al, 1992]. PVC loses by a wide margin when compared to other materials used for windows and flooring in a study commissioned by The Ministry for Housing in a German province. [168, MOH, 1992].

The authoritative study prepared by the Danish EPA compares PVC unfavourably with a range of other materials including wood, rubbers, paper and card and a selection of plastics. Only aluminium gets such a bad report [169, EPA, 1993].

The PVC industry has done its own favourable life-cycle analyses (LCA), often neglecting to include the high energy requirements of chlorine production.

The Bad and the Ugly: various plastics

Most plastics, today, are products of the unsustainable and environmentally damaging petrochemical industry. As such, they cannot be regarded, in the long term, as materials of a sustainable society. Although most plastics today are oil-based, it is possible to make bio-polymers or plastics from plant materials such as cellulose. Bio-polymers can also be produced by microorganisms. In the 1930s, Henry Ford built one of his first cars from cellulose-based plastic derived from soy fibre.

The Italian company, Ferruzzi sells a biodegradable plastic based on a mixture of 70percent corn starch with other biodegradable additives. ICI sells bio-plastics under the trade name 'biopol' which are made from chemicals obtained from bacteria fed on sugar. Both companies market their biodegradable plastics to the packaging industry.

Most of the research into bio-polymers is to achieve biodegradable plastics for short-life products, such as packaging and disposable goods, rather than developing more durable biopolymers. Moreover, present polymer research is going down the unsustainable path of genetic engineering, even though bio-polymers can be made using traditional biotechnology. Today, R&D is focused on making bio-polymers from genetically modified organisms (GMOs) fed on an assortment of diets, instead of durable bio-plastics which could meet some building specifications. The release of GMOs into the environment poses a threat to the natural balance of ecosystems, biodiversity and ultimately, human and animal health.

Until traditional bio-polymers are more durable and more widely available, society has to live with petroleum-based plastics. These plastics are not uniform in terms of their potential to cause environmental damage. When evaluating plastic alternatives to PVC, the entire life cycle of the alternative must be considered. (See Annex C)

Using the criteria of chlorine and additives content, plastics can be considered in terms of a hierarchy of 'environmental evil', crowned by PVC. Lower down in this hierarchy one would probably find polyurethane (PUR), polycarbonate and ABS - whose life cycles are almost as hazardous as that of PVC. At the base of the hierarchy would be those plastics with low or no chlorine content and few additives, such as polyethylene (PE) and polypropylene (PP). The absence of chlorine lessens both the toxicity and the energy intensity of the plastic. As we have seen, the chlor-alkali process used to make chlorine uses a lot of energy. The reduction in the quantity and assortment of additives increases the toxicity of the plastic and hampers its recycling (Annex C)

The durability of petroleum-based plastics means that their most appropriate use is in long-life products, such as building materials - at least until better materials are found. Their inability to 'decompose' in landfills and high potential for generating toxic leachate means that they should not be dumped. The hazards associated with burning plastics, containing many different toxic additives closes the incineration route.

This only leaves recycling. The absence of chlorine and large amounts of various additives facilitates true plastics recycling - where a plastic product can be reprocessed at the end of its first life into the same product. It also reduces the need for corporate green-washing to disguise 'down-cycling' and 'sham recycling'.

Clearly, some plastics are less environmentally damaging than others. These could be considered 'transition materials', until better materials are discovered or traditional materials reintroduced.

Indeed, the polypropylene (PP) and polyethylene terephthalate (PET) industries are highly buoyant in India. Technologists are optimistic about the range of products that PP, in particular can make, "The range of products made from PP is extremely wide. The basic polymerisation process.. for PP offer polymer scientists an opportunity to nearly tailor-make a grade for any specific application combining the physical, chemical and thermal properties unique for that application" [15, Hindu, 1996]. Medical applications, packaging, stationary products, fabrics, sacking, kitchen-ware, pens. The list is long and can surely replace PVC for many soft applications.

There is currently only one domestic manufacturer. Indian Petrochemicals Corporation Ltd (IPCL) but they are expanding production. Reliance is commissioning a huge PP plant at its Hazira, Gujarat petrochemical complex and there are four other companies in the field, including NOCIL. All these, of course, are also major players in PVC production.

Section 6 Environmental Policy and Regulation

"The task is not to find substitutes for chemicals that disrupt hormones, attack the ozone layer, or cause still undiscovered problems (though it may be necessary to use replacements as a temporary measure). The task that confronts us over the next half century is one of redesign"

Theo Colborn 'Our Stolen Future'

Introduction

Many organochlorines have already been phased out or have been severely restricted in use when the dangers were acknowledged: the industrial lubricant PCB; pesticides DDT, the drins, chlordane, heptachlor and toxaphene; the wood preservative pentachlorophenol; and ozone layer destroying CFCs, are some examples.

Environmentalists point to the huge quantities of other organochlorine pesticides such a lindane and benzene hexachloride (BHC) that are still in use together with the many other groups of organochlorines still being manufactured: the chlorinated paraffins, used as softener in PVC production; chlorinated napthalenes used as industrial lubricants; chlorinated benzenes that behave environmentally like the chlorinated pesticides; chlorinated toluenes mostly used as intermediaries in pharmaceuticals; and chlorinated phenols which are ubiquitous in pulp mill effluent.

There are also the ubiquitous by-products such as the dioxins and the chlorinated benzenes, created by a myriad of different ways in association with chlorine.

6a Limitations of Pollution Control

6a.1 Case by case

Industry argues that we have to look at chemical-by chemical risks to the environment and human health (ie not at organochlorines as a class of chemicals). Therefore most assessments of the dangers of chemicals relate to the study of single chemicals, often through laboratory studies of their effect on single animal species. This bears little relationship to complex aquatic ecosystems receiving industrial wastes as a means of dilution and dispersal.

As we have seen, regulatory authorities worldwide usually set only very generalised physical, biological and simple chemical parameters such as pH, conductivity, dissolved and suspended solids, BOD and COD, nitrogen and phosphorus and a few named metals when setting limits and qualifying discharges to water, air and landfill from industry.

Regulatory limits for the same industrial processes vary from country to country depending on analytical knowledge, expertise and available resources. They are mostly set, not by the criteria of protecting the environment, but depending on what resources are available and mostly what industry will accept.

These lists inevitably only contain those substances already identified as causing harm. Very few of the 60,000 chemicals in common use have been examined for their toxicity, persistence or potential to bioaccumulate.

In any industrial waste stream, the complexity of the effluent is such that attempts to define or limit the number of organochlorine compounds discharged or produced by further chemical reactions within the effluent stream, would defy any regulatory authority. Most of these chemicals are rarely fully understood or monitored for, and eco-toxicological information is mostly non-existent.

As scientific detection methods improve and eco-toxicological knowledge increases, it has become apparent that there are no safe levels for certain chemicals, notably dioxin and other organochlorines.

6a.2 Failure of Environmental Laws

Pollution Control remains the over-riding strategy to limit environmental damage by industrial chemicals in India.

Chief spokesperson for the Confederation of Indian Industry (CII), K.P. Nyati seems content with the existing framework for control of pollution in India: [111, Nyati, 1995]

"Environmental problems in India are no different than were faced by developed nations in their early period of industrial consolidation. What is different, however, is the fact that India has to and is accomplishing the industrial and economic progress while safeguarding the environment which many of today's highly industrialised nations, at that point in time, didn't have to - at least not as vigorously..."

"There are nearly 200 statutes in the book of law that directly or indirectly deal or touch environmental protection... As regards effluent and emission standards, they are both general as well as industry sector specific. What is important to note here is that most of these standards are as strict as those imposed in USA, Germany or elsewhere in the world... The water pollution standards are very comprehensive and cover almost all the pollution parameters right from BOD,

COD, heavy metals to chlorinated toxics... Indian environmental laws are not only well written but are also quite comprehensive in nature."

The evidence from conversations with pollution control engineers, regulators and our own sampling and analyses shows in practice a diametrically opposed picture. At best K.P.Nyati's statements are based on wishful thinking. At worst, in regard to water pollution parameters covering chlorinated toxics, these remarks promulgate downright mis-information. At regional and local levels where these laws are implemented, equipment and testing facilities are at best basic, but more often non-existent. Primary effluent treatment does little to limit the entry of persistent organics into the environment.

He does however recognise that "in the beginning, as it normally happens, the enforcement is weak" and states that only "45percent of the medium and large industries are in compliance with environmental regulations". However, he goes on to say "the compliance record of medium and large industries in 18 categories of highly polluting industry is far better than average. Over 80percent of these units today are complying." [111, Nyati, 1995]

Given the absence of significant data it is difficult to see if this latter statement is true or false. Certainly even if end-of-pipe measurements show compliance with certain of the proscribed parameters, these parameters themselves remain too generalised to identify key chemical pollutants, especially the persistent organics. Even if we look at degrees of reaching or surpassing set standards, evidence from the pulp mill sector alone shows that a key proscribed parameter (for TOCl) is not even being tested for, let alone analyzed or reported: compliance record zero percent. The same applies to mercury discharges from the production of chlorine gas.

Box 6.1 Highly Polluting Industry Sectors.

1. Aluminium smelters
2. Caustic soda units
3. Cement plants
4. Copper smelters
5. Dyes and intermediates manufacturers
6. Fermentation units
7. Fertilisers
8. Integrated iron and steel plants
9. Leather (tanneries)
10. Oil refineries
11 Pesticide manufacturers
12. Petrochemicals
13. Pulp and paper
14. Pharmaceuticals
15. Sugar
16. Sulphuric acid plants
17. Thermal power plants
18. Zinc smelters

Source: Ministry of Environment and Forests

6a.3 Failure of Enforcement

Industry not only fails to comply with legislation, such as environmental audit reporting, but, as we have seen with pulp mill organochlorine discharges, they also fail to install basic analytic facilities to measure contamination at the end-of-pipe. Control authorities are then unable to use what few teeth they have to enforce legislation.

"Although enforcement has improved significantly over the past several years in some of the more industrial states, the improvement is limited to nontoxic air and water pollution from large and medium-sized private industrial units. Regulations for public units are poorly enforced due to political interference in the functions of the state boards. Most boards lack the capacity to monitor and enforce regulations related to hazardous waste management. As with other enforcement activities in India, corruption is pervasive."[112, Cambridge, 1996]

"Although the increasing number of environmental laws require the (Central and State) boards to operate as environmental management agencies, their operating philosophies have changed little since the boards were established. Most of the boards have inadequate facilities and infrastructure. For example, while most of them have basic testing equipment at the central and state headquarters, this capacity is lacking at regional and local offices". [112, Cambridge, 1996]

It is hard not to feel some sympathy for hard-pressed officials in both the central and state pollution boards. Mr Jain, Law Officer for the Mahahrashtra Pollution Control Board (MPCB), is pessimistic about his the effectiveness of his work, "We are not very good at handling hazardous wastes. We are lagging behind. The entire burden of locating landfills and maintaining them is shifting onto the shoulders of state government. Frankly not much has been done in that direction. Right now, the waste is being taken to unidentified sites. Who should carry out Environmental Impact Assessment and prove the case against industry?"

Regarding the policing of industrial operations, he appears even more depressed. "I am in the MPCB for 15 years and am unable to control pollution. How can I be successful, with 200 people to control 200,000 industries. It takes a minimum of 3 days to do an environmental audit on a company such as NOCIL. Often I have to rely on industry to do its own monitoring, especially for complex hazardous chemicals." (Interview 13.3.96)

6a.4 Self Regulation by Industry

Faced with increased pressures from a public demanding a clean environment and the high costs of an effective policing regime, governments are increasingly accepting industry's self regulating regimes. Companies proudly display their 'green' credentials by adopting the ISO 14001 standard on Environmental Management Systems. But this standard does not mean evaluation of the environmental impacts of processes, production methods or the even the impact of a product.

Responsible Care

Responsible Care is the name the chemical industry gives to its programme of environmental self-regulation. It originated in Canada and was adopted in the US in 1989 in the wake of the Exxon Valdez oil spill disaster. The concept has now spread throughout the industrialised world: from Europe through to South and South-East Asia. India adopted the programme in 1992.

Adopted codes of management usually include:

- Community awareness - to ensure emergency preparedness, primarily for communities close to plants but also to improve communication with general public.

- Process safety- intended to prevent fires, explosions and accidental chemical releases.
- Employee health and safety - intended to protect the health and safety of chemical workers.
- Waste and release reduction - designed to achieve continuous reduction of all contaminants released to air, water and land from plants and distribution centres.
- Product stewardship - to make health, safety and environmental protection an integral part of the design, manufacturing, marketing, distribution, use, recycling and disposal of products.

In practice, these programmes are part of a chemical company's public relation exercises - designed to improve image, but they do not work. In the US the chemical industry is not trusted by the public. Only the tobacco industry had a worse rating in a 1994 poll. A poll in the UK in 1996 showed that only the nuclear industry was considered less reputable.

Although there has beeen some improvement in environmental performance, these programmes are mostly public relation exercise, they co-opt the language of environmentalists but carefully do not define criteria or clear goals. They mention pollution prevention and reduction , though not phase-outs and bans. In principle, they want to create safe products, there are no criteria for what constitutes as a safe product.

There is still the assumption that the only thing wrong in the chemical industry is that there are too many 'incidents'. These 'incidents' are what inflames the public and must be avoided. Northern multinationals are the most active in this effort to reposition themselves in terms of public perception. They address the image problem by investing in the following type of activity:

- appointment of environmental office;
- using environmental themes in advertising;
- market research project to measure public opinion;
- establishment of "codes of conduct"

Above all "Responsible Care" is a means of avoiding command and control regulation; in particular public disclosure of full chemical-specific information about usage and emissions of chemicals.

As spokesperson for Greenpeace USA, Bill Walsh said to Chemical Week magazine in July 1991, "Responsible Care is like the drug pusher giving people clean needles. It does nothing to wean people from a destructive habit. It just makes them feel comfortable about a practice that is inherently bad for the environment."

6a.5 Enter the Courts

In recent years in India, we have seen the judiciary, in the form of the Supreme and High Courts responding to Public Interest Litigation (PIL) and essentially usurping the role of the pollution control authorities and the Ministry of Environment and Forests (MOEF). Polluting plants are being moved out of metropolitan areas , some 40,000 in Delhi alone; tanneries closed in Tamil Nadu, H-acid plants in Rajasthan and a host of industries along the Ganga. These measures reflect the urgency of the industrial pollution problems faced by India; they are not informed reactions to preventing pollution. "The judiciary has been unable to deal with policy issues,

largely because it lack the technical background needed to evaluate environmental impacts." [112, Cambridge, 1996].

Faced with closure and loss of jobs, industrial units, often small-scale, are usually not offered advice on how to prevent pollution by means of process change or internal housekeeping measures. They are simply told to go elsewhere and continue as before. Out of sight and therefore out of the public mind.

"Shifting will be no solution", says J.R. Jindal, President of the Delhi Factory Owners Federation. "Wherever we go, they will not accept us. We must remove the problem from the root. My argument is advise them and provide them with opportunities to improve." [170, Uniyal, 1996].

6a.6 Conclusions

To increase monitoring, to extend the list of controlled substances, to set new threshold limits and investing in the latest analytic techniques, is not only costly and time consuming - further stretching the limited resources of pollution control authorities - but ultimately tackling the problem the wrong way round.

As we have seen most industrial processes involving chlorine will lead to a complex effluent discharge which includes recombination of compounds into further by-products, sometimes numbering thousands of differing chemicals. This is impossible to quantify and qualify on an individual chemical basis and the only realistic regulatory approach is to treat organochlorines as a priority class of chemical for phaseout.

6b. The way forward to Clean Production

To eliminate toxic pollution, we need to look upstream at processes and products. This needs to be done systematically initially involving a series of in-plant investigations. Research in 1992, at Erasmus University in the Netherlands revealed that some 70percent of current wastes and emissions from industrial processes can be prevented at their source. This can be achieved by using technically sound, economically profitable procedures and technologies which are now available."

6b.1 A case study of pollution prevention

Pollution prevention gets some attention through funding of a cleaner production unit at The National Productivity Council (NPC) but this funding only amounts to some 25percent of their costs. In 1993/94, the DESIRE project, sponsored by United Nations Industrial Development Organisation (UNIDO) and conducted by the National Productivity Council was carried out to demonstrate the potential for waste minimisation in Small Scale Industries (SSIs) in India. Three industrial sectors were targeted; agro-based pulp and paper, textile dyeing and printing and pesticides formulation. [171, Chandak, 1994].

NPC claims that about 300 waste minimisation measures were implemented or were in progress at the close of the 15 month implementation period. However, clearly this was a difficult process where a number of obstacles to progress were identified including:

- Owners of small enterprises tend to dominate all decision making, undermining managerial responsibility. Even for low cost waste minimalisation, approval has to be obtained from the owners.
- The job security in small-scale mills is more dependent on the whims or fancies of the employer than on the performance of the employee. The people are therefore more worried about retaining their job than taking on new and possibly risky ventures.
- Production personnel are not routinely involved in waste minimisation and environmental activities. Employees lack initiative. There is an almost total lack of systematic training of employees to upgrade job skills. Employees are, therefore, unable to comprehend new subjects such as waste minimisation.
- Overburdening of technical staff and poor remuneration results in high turnover; to the detriment of building effective team experience.

In general, the report concluded, it appears that industry is not concerned with long term strategies but will only install "house-keeping" measures or process changes if immediate improved profits will result. However,this programme did create "Rs 35.8 million in savings and a significant reduction of pollution load in all sectors".

Lack of data

One of the problems in the above DESIRE project outlined by the NPC was: "Due to lack of in-house facilities such as instruments for on-site monitoring and analytical facilities, SSI's have to rely on expensive external agencies for data collection. Due to no record or poor record keeping of water, energy, material consumption, inventory of chemical, fuel and raw material, the Waste Minimisation level auditing process becomes tedious and the process has to start from collecting baseline data."

The World Bank, in a recently commissioned report, argues, "No comprehensive data exists on either total industrial loads (ie total pollution output) or pollution intensities (pollution emitted per unit of output in India) - a constraint to full understanding of the extent and cost of the industrial pollution problem." [172, Brandon and Hommann, 1995].

Need for public participation

Without such information it is difficult to see how industry, government and the public can participate in effecting change. Indeed, this absence of information is one of the key reasons that the NPC could state that, "pressure from environmental groups and the public in general is necessary for proper environmental management. In the absence of such an approach the management tends to adopt a lackadaisical approach."

In a previous report [112, Cambridge, 1996], the World Bank mentions that the Government of India addresses public partnership in environmental decision-making as a priority.

The report supports the view of the NPC, "Given that enforcement agencies are weak, the capacity of the public to bring pressure on polluters must be strengthened. This cannot happen without a formal and transparent public disclosure process."

Need for public access to information

It doesn't need a World Bank Report to know that "access to what information there is tends to be suppressed by government and access to documentation by the public denied - even in the face of legislation designed to bring the public into decision making processes." [112, Cambridge, 1996]

Both Greenpeace and numerous environmental groups we have talked to have experienced being denied access to such simple information as "consents to discharge" and environmental audits.

6b.2 Community Right to Know

Legislation such as the USA's Resource Conservation and Recovery Act (RCRA) and The Superfund Amendments and Reauthorization Act (SARA) has forced industry to locate, identify and quantify usage and emission of hazardous chemicals; shifting the focus of waste-related data collection from end-of-pipe to plant processes.

In 1986 the US enacted The Emergency Planning and Community Right to Know Act, ironically in the wake of the Union Carbide chemical disaster in Bhopal. This law requires companies to develop emergency response plans through a committee which represents a cross-section of the community. These committees have virtually unlimited access to the toxic chemicals manufactured, used, stored, or discharged by facilities in their area.

The Act's other main function is to make publicly available the Toxic Release Inventory (TRI). The Act stipulates mandatory reporting of releases. Companies must fill in annual forms giving the quantities of listed chemicals they emit to water, land, air, sewers. They must account for chemicals transferred to incineration, deep-well injection and to on-site and off-site recycling and recovery of chemicals and materials. The US EPA is currently expanding the legislation to include more industrial plants and extending the list of chemicals to be accounted for.

This legislation not only provides regulatory authorities and NGOs, through the US Freedom of Information Act, with stronger sticks to beat polluting industry with but tools by which the same industry can more easily reduce pollutants from storage, loading transfer and pollution control operations, as well as the manufacturing process itself [173, Kenworthy and Schaeffer, 1990].

Conclusion

Since pollution control strategies have focused on the end-of-pipe and self-regulations are clearly inadquate, the government needs to re consider its pollution strategy from control to limitation to prevention. Government cannot rely upon either control strategies or market forces to lessen the burden of toxic pollution. Decisions have to made at the very highest level of government as to what products and industries are appropriate and desirable to continue with and develop.

This is particularly true in India now in its expansive process of liberalisation, attracting and building new industry to provide essential goods and services and improve the material lot of a huge deprived population.

6c The way forward: Prevention not Control

The Government of India's stated policy is to 'prevent pollution at source':

Box 6.2 Policy Statement for Abatement of Pollution

The Government of India issued a Policy Statement for Abatement of Pollution in February 1992. The policy statement affirms the government's intention to integrate environmental and economic aspects in development planning, with stress on the preventative aspects of pollution abatement, and the promotion of technological inputs to reduce industrial pollutants. The overall policy objective is to integrate environmental considerations into decision making at all levels:

Specific steps identified to meet this objective are:

* Prevent pollution at source.

* Encourage, develop and apply the best available practicable solutions.

* Ensure that the polluter pays for the pollution control arrangement.

* Focus protection on heavily polluted areas.

* Involve the public in decisionmaking

* Increase the safety of industrial operations.

To achieve the objectives, maximum use will be made of a mix of instruments in the form of legislation and regulation, fiscal incentives, voluntary agreements, educational programs and information campaigns. The emphasis will be on increased use of regulations and an increase in the development and application of financial incentives.

Source: Government of India, March 1992

However in order to achieve this goal, a number of steps have to be taken. Firstly there needs to be full disclosure of chemical, material and energy - use including waste - by industry. This information must be available to the public. Secondly, the government must embrace the Precautionary Principle.

For too long the old assimilative capacity approach has predominated in India. The concept that the environment has a capacity to absorb and breakdown limited amounts of pollutants predominates in Indian environmental policy; much to the silent approval of industry.

"The vast land mass...the long coastline render Indian costs of treating pollutants arising from industrial activity far less than is the case of industries abroad" [175, Subrahmanian, 1996].

6c.1 Precautionary Principle

While industry demands a cause and effect scenario: "Show us what chemical x is doing and we will respond accordingly", governments, international regulatory bodies and the scientific community have realised that it is impossible to behave responsibly and protect the environment and human health on that basis. By the time the effects of persistent pollutants are known it is already too late. Witness the devastation still being caused to marine wildlife by PCBs and the threat to human fertility by exposure to DDT.

International policy makers therefore adopted the Precautionary Principle, with the aim to prevent pollution. It is a guideline for utilising available scientific information, with due consideration to uncertainties and missing information, to predict the potential for chemicals entering the environment to cause harm. It suggests, as does the IJC (International Joint Commission), a reverse onus of responsibility. Within the guideline it determines progressive reductions of contaminants entering the environment, by implementing clean technologies.

The term Precautionary Principle was first raised by the German delegation at the first North Sea Conference in 1984 when faced with the problem of dealing with one of the world's most contaminated seas. Since then the approach has been adopted by a number of international regulatory regimes including, the Rio UNCED Declaration (1992), The Oslo and Paris Commissions (1989), The London Convention (1991), The Bamako Convention (1991), The Barcelona Convention (1991), The UNEP Governing Council (1989), The Bergen Declaration (1990) and The Nordic Council (1989).

Table 6.1 Assimilative Capacity and Precautionary Approach

Assimilative Capacity Approach	Precautionary Approach
Assumptions:	**Assumptions**:
Chemical contamination of the environment is acceptable up to the point of serious or irreversible harm.	Chemical contamination of the environment is to be avoided.
The environment has a definable capacity to adsorb and assimilate chemical contaminants without harming the biosphere.	The variety and complexity of the chemical contaminants, and the variety and complexity of biological species and interactions, make it impossible to accurately predict the effects of specific levels of contamination.
Even with scientific uncertainty regarding the effects of pollutants, it is possible, by risk analysis to determine safe and unsafe (or acceptable and unacceptable) levels of particular contaminants entering the environment.	Because of the scientific uncertainties it is not possible to define safe and unsafe levels of contamination, and acceptable levels derived from incomplete information are not protective.
Elements:	**Elements**:
Risk analysis leading to acceptable levels of input of contaminants.	Prevention of contaminants entering the environment. Use of scientific information to prioritise reduction efforts.
Action after proof of damage.	Action before damage and before conclusive scientific proof (action based upon potential to cause damage).
Burden of proof upon those questioning a polluting activity.	Burden of demonstration upon those proposing the activity.
Implementation through discharge limits - usually based upon water, air and soil concentrations, not total output.	Implementation through clean production methods (reducing contamination at source).
Consequences:	**Anticipated consequences**:
After decades of this regulatory approach global water and soil is suffering increased degradation.	Pollution will decrease if sources of contamination are eliminated at the design and production level of industrial processes.

Source: Greenpeace International 1994)

6c.2 International Legislation

Increasing the international community is responding:

- The International Whaling Commission (IWC) passed a resolution in 1993, calling on "Contracting Governments to take all practicable measures to remove existing threats to the marine environment and adopt policies for the prevention, reduction and control of degradation of the marine environment, including in particular, means to eliminate the emission or discharge of organohalogen compounds that threaten to accumulate to dangerous levels in the marine environment."

This followed the United Nations Conference on Environment and Development (UNCED) in Rio de Janeiro, Brazil, 1992 that in chapter 17 of Agenda 21 stated:

- "Priority actions by States may include: 17.28 (d), Eliminating the emission or discharge of organohalogen compounds that threaten to accumulate to dangerous levels in the marine environment."
- In the same year The Paris Commission, the regulatory body of marine pollution in the North East Atlantic and in 1993 The Barcelona Convention, regulating pollution in the Mediterranean, called for the elimination of inputs of organohalogens into their respective waters.

The Ministerial Declaration of the North Sea Conference went further at its Fourth Meeting in 1995:

- "This implies the prevention of pollution of the North Sea by continuously reducing discharges, emissions and losses of hazardous substances thereby moving towards the target of cessation within one generation (25 years) with the ultimate aim of concentrations in the environment near background levels for naturally occurring substances and close to zero concentrations for man-made synthetic substances."
- Previously, in 1994, President Clinton threw a bombshell at the Chlorine Industry in the USA when, citing growing evidence that linked environmental contamination, "not only cancer but also to neurological, reproductive, developmental, and immunological effects" he called for a national strategy to "substitute, reduce or prohibit the use of chlorine and chlorinated compounds" in his proposal for The Clean Water Act, 1994.

This followed recommendations made by the International Joint Commission on the Great Lakes (of Canada and The USA) in 1992:

- "It is prudent, sensible and indeed necessary to treat these (chlorinated organic) substances as a class rather than as a series of isolated individual chemicals. Further, in many cases, alternative production processes do exist. The commission concludes that the use of chlorine and its compounds should be avoided in the manufacturing process. The Commission therefore recommends that the Parties, in consultation with industry and other affected interests, develop timetables to sunset the use of chlorine and chlorine-containing compounds as industrial feedstocks.

The recent eighth biennial report of the International Joint Commission (IJC) 1996 is more specific:

- "The time and resources required to document contamination and injury to establish linkages between cause and effect has inhibited action in a public health policy. A comprehensive approach to all persistent toxic chemicals is not only the preferred way to protect the integrity of the ecosystem and public health but the only effective way." And:

"As a society, we cannot continue protracted debate while the actual or even suspected injury to living species continues to occur. Yet this is precisely what occurs and will occur until Governments address classes of chemicals rather than a few chemicals at a time."

The IJC proposes a reverse onus of responsibility:

- "The burden of proof of potential risk or proven harm to health or environment has been the responsibility of environmental management agencies - agencies with limited resources. Reversing the onus, whereby the proponent manufacturer, importer or user would have to prove that suspected persistent toxic substances are not and will not be more harmful, is a more reasonable and logical approach."

6c.3 Phasing out chlorine

Apart from these broad framework policies, mostly aimed at protecting fresh water and the marine environment, (the ultimate sink for these chemicals), a number of regional forums, such as the European Union (EU) and national governments have enacted legislation to ban and restrict uses of both organochlorines and the products that they are used for.

It is increasingly evident that end-of-pipe control strategies, for example limiting discharges on a chemical-by-chemical basis, as employed by the CPCB and State Pollution Control Authorities, will have little impact on removing industrial pollutants from our lives. Only when chemical usage in processes and products are banned and the bans implemented, will the ecosystem have chance to recover.

Austria has banned all chlorinated solvents in "open use" (like in paints and wood preservatives) since 1992. Production, use, import of the wood preservative pentachlorophenol (PCP) has been banned since 1991. Germany, USA, Netherlands, the EU and Sweden have also banned PCP. Hexachloroethane (HCE) for the non-ferrous metals industry is generally banned in Europe. The ban on chlorinated solvents has become law in Sweden. As we shall see, most chlorinated pesticides and PCBs have been banned in the industrial north. The use of PVC in packaging, some "soft" applications and buildings is being restricted by an ever increasing number of municipalities and northern governments.

However, these bans mostly reflect environmental awareness in particular countries, and the availability of alternatives and substitutes. They are not a systematic way of eliminating the problem of organochlorine pollution. In order to phase-out these chemicals in an orderly manner, a priority list needs to be drawn up, on the basis of the criteria we outlined in Section 2.3. A number of socio-economic parameters also have to be considered, the retraining and redeployment of workers being of the utmost importance.

6c.4 Economic instruments

Proposing and implementing bans and phase-outs requires strong political will and a high degree of consensus in society, two ingredients lacking in Indian environmental policy.

However, in order to tackle pollution either at end-of-pipe, during processes or in use and disposal of products, a number of instruments are available which are more direct, less costly to operate, that the pollution control regime.

- Effluent charges force industry to look at recycling effluent within plant or process modifications that can avoid extra add-on costs.
- Product charges or differential taxation are very effective devices to drive prodution into more environmentally sound alternatives. We have seen the success of 'eco-taxes' in Belgium which stopped the use of PVC bottles of mineral water.

Fiscal instruments are traditional tools of Indian economic policy as applied through customs duties and direct levies on goods.

One increasingly valuable mechanism is Extended Producer Responsibility: an emerging principle for a new generation of pollution prevention policies that focus on product systems instead of production facilities

6c.5 Extended Producer Responsibility

The aim of EPR is to encourage producers to prevent pollution and reduce resource and energy use at each stage of the product life-cycle through changes in product design and process technology. In its widest sense EPR obliges producers to be responsible for the environmental impact of their products. This includes upstream impacts, arising from the choice of materials and from the manufacturing process and downstream impacts, from the use and disposal of products. Producers accept their responsibility when they accept legal, physical, or economic responsibility for the environmental impacts that cannot be eliminated by design. In particular accepting responsibility for their products and the waste generated by their products at the post-consumer stage of their life-cycle.

The model example of EPR is product take-back where a producer takes back a products at the end of its useful life (when discarded) either directly or through a third party. Other terms used are "product liability" or "product responsibility."

The idea is not, in principle, new to India where refundable deposits on refillable glass bottles is common. However, little thought has been given to applying the same principle to cars, computers, washing machines, Ruffles and Uncle Chipp potato chip packets and the plethora of consumer goods being sought and manufactured for the growing ranks of the middle classes.

The EU has recently adopted this approach in the recent review of the EU Waste Management Strategy. The principle of producer responsibility is recognized as a key element of a precautionary approach to waste management. The reason given is that the waste management potential of a given product is largely determined by decisions made by the manufacturer concerning the composition and design of the product, in the first case.

EU Commissioner stated, "The recognition of the principle of Producer Responsibility in the review of the Waste Management Strategy is particularly important. Many manufacturers have for too long considered the problems of waste management as if it was some body else's problem. It is important to clearly underline that is also their problem. We cannot come to terms with the

ever growing amounts of waste in a rational way, unless the concerns for waste minimisation and recovery is so-to-speak built into the product from the start. This is a challenge to industry which has to be taken seriously." [174, EU, 1996]

A small step in the right direction has been recently taken by the Supreme Court in its closure orders to tanneries in Tamil Nadu. Polluting factories have been told not only to compensate affected people but pay for damage done to the environment. Strict rules of liability for not preventing pollution have also been spelt out. [170, Uniyal, 1996]

Cost -effective recycling in the future will require product design changes that reduce disassembly time and increase the reuse and recyclability of products, including;

- product simplification
- standardisation of components, product configuration
- modular designs, including components for reuse
- standardisation of material types.

Box 6.3 Policies embodying the principle of EPR

Regulatory instruments that embody EPR can include:
* mandatory take-back;
* minimum recycled content standards;
* secondary materials utilisation rate requirements;
* energy efficiency standards
* disposal bas and restrictions;
* materials bans and restrictions; and
* product bans and restrictions.

Economic instruments that embody EPR include
* advance disposal fees;
* virgin materials taxes;
* removing subsidies for virgin materials; and
* environmentally preferable products procurement.

In rmation instruments that embody EPR include:
* seal-of-approval types of information labelling (Green Seal, Blue Angel);
* environmental information labelling (energy efficiency labelling, CFC use);
* product environmental profiles that pass from one stage of the life-cycle to the next;
* product hazard warnings; and
* product durability labelling.

Most information approaches place the primary responsibility on the producer to develop and provide information, either voluntarily for market advantage or as a regulatory requirement.

Source: Extended Producer Responsibility. Greenpeace International 1995

With the planned expansion of industry manufacturing toxic products in India it is imperative that government starts to make industry responsible for dealing with products at the end of their

lives, as means of forcing industry to only produce materials that are environmentally compatible. In particular we are concerned with the huge expansion of the PVC industry whose products, either directly in buildings, agriculture or packaging or indirectly as constituent parts of consumer goods such as cars and "white goods" (washing machines, refrigerators etc.) are set to increasingly affect all in India.

6c.6 Clean Production

Beyond this we have to understand that a Clean Production strategy involves looking further than clean technologies. Clean Production is a means of implementing the Precautionary Principle by adopting a holistic and integrated approach to environmental issues centred around the product. This approach recognises that most of our environmental problems- for example global warming and loss of biodiversity as well as toxic pollution - are caused by the way and rate at which we produce and consume resources. It also acknowledges the need for public participation at all levels of political and economic decision making.

Table 3.2 Clean Production Criteria

Clean Production systems for food and manufactured products are:

- non toxic;
- energy efflicient;
- made using renewable materials which are routinely replenished and extracted in a manner that maintains the viability of the eco system and community from which they were taken;
- made from non-renewable matereials previously extracted but able to be reprocessed in an energy effieient and non-toxic manner.

The products are:

- durable and reusable;
- easy to dismantle, repair and rebuild;
- minimally and appropriately packaged for distribution using reusable or recycled and recyclable materials.

Above all, Clean Production systems:

- are non-polluting throughout their entire life cycle;
- preserve diversity in nature and culture;
- support the ability of future generations to meet their needs.

The life-cycle includes:

- the productive/technology design phase;
- the raw material selection and production phase;
- the product manufacture and assemblage phase;
- the consumer use of the product phase;
- the societal management of the materials at the end of the useful life of the product.

Source: What is Clean Production? Greenpeace October 1995

The visionary concept of clean production has evolved in the industrial north where over-consuming life-styles have led to enormous environmental degradation and resource depletion on a global scale. However it is generally recognised that India faces a grim future unless

environmental issues, in the widest sense are adequately addressed. The recent report from the World Bank, spelt it out:

"On the pollution side, urban air, water, and solid waste problems are leading to significant health impacts, and the marine environment is severely stressed by industrial pollutants. On the resource side, crop yields are declining on what were previously some of the most productive soils because of soil erosion and salinity; forests have been depleted and degraded for agricultural, livestock and fuelwood purposes (although important efforts at reforestation are also taking place); rangelands are increasingly deterioriating; and the country's rich flora and fauna species are being depleted, some of which now are in danger of extinction" [172, Brandon and Hommann, 1995].

Further expansion of toxic industries will add to this burden. India has a long tradition of extending hospitality to visitors, but we hope that one stranger, the chlorine industry, is increasingly made to feel unwelcome.

ANNEX A CHLOR-ALKALI UNITS IN INDIA

Table from the Chlor-Alkali Manufacturer's Association of India

Name of Unit	Registered Office	Factory
The Andhra Sugars Ltd	Venkatrayapuram P.B. No:102, Tanuku-534 215 (AP) Ph: 08819-24911-15 & 24333	P.O. Kovvur -534 350 Distt-West Godavari Ph: 08817-31597/98
Atul Products Ltd	Ashoka Chambers Rasala Marg Mithakhali Cross Rd, Ellisbridge Ahmedabad - 380 006 (Gujarat) Ph: 0272-449294/401621	P.O. Atul - 396 020 Distt - Valsad (Guj) Ph: 02632-83261-5
Ballarpur Industries Ltd	Thapar House, 124 Janpath New Delhi - 110 001 Ph: 011-3328332 Gram: SPIRITUAL	P.O. Binaga (Karwar) Uttara Kannada - 581 364. Karnataka Ph: 08382-26236 Gram: SPIRITUAL
Bihar Caustic & Chemicals	Garhwa Road P.O. Rehla - 822 124 Distt - Palamau (Bihar) Ph: 06562-22582, 87211	Garhwa Road P.O. Rehla - 822 124 Distt - Palamau (Bihar) Ph: 06562-22582, 87211
Birla VXL Ltd. (Saurashtra Chemicals)	Aerodrome Road Jamnagar - 361 006 Ph: 0288-551480-83	Birlasagar Porbander - 360 576 Gujarat Ph: 02686-21735/37
Century Rayan	Century Bhawan Dr. Annie Besant Road Worli Mumbai - 400 025 Ph: 022-4300351	Murbad Road P.B. No: 102 Shahad - 421 103 Distt. Thane Ph: 0251-546570/77
Chemfab Alkalis Ltd	TEAM House, GST Road Vandalur, Madras-600 048 Ph: 044-2376323/24/26	Gnanananda Place Kalapet, Pondicherry Ph: 0413-65111-14
Chemplast Sanmar Ltd	8, Cathedral Road Madras - 600 086 Ph: 044-8273333, 8277332	Mettur Dam-636402 Distt-Salem (TN) Ph: 04298-22296
DCM Shriram Consolidated Ltd (Shriram Fert. & Chemicals	Kanchenjunga Building 18, Barakhamba Road New Delhi - 110 001 Ph: 011-3316801/2	1) Shriram Nagar Kota-324004, Rajasthan Ph:0744-423391/8 2) 749, GIDC Indus Estate, Jhagadia Distt-Bharauch, Gujarat Ph: 02645-20355

DCW Limited	Nirmal, 3rd Floor 241, Backbay Reclamation Nariman Point Mumbai - 400 021 Ph: 044-2871914/1916	1) Dhrangadhra 363316, Gujarat Ph:0275-422387 2) P.O.-Arumuganeri Sahupuram Distt-Chidambara
Durgapur Chemicals Ltd	6, Little Russel Street Calcutta - 700 071 Ph: 033-2471556/1662	Dr. Hanemann Sarani Durgapur-713 215 Distt-Burdwan (W.B) Ph: 033-6668/69/70
Grasim Industries Ltd.	Birlagram P.O. Nagda-456 331 (M.P) Ph: 07852-46760/66	Birlagram P.O. Nagda-456 331 (M.P) Ph: 07852-46760/66
Gujarat Alkalies & Petrochemicals Chemicals Ltd	Yashkamal Sayajiganj P.B. No: 2505 Vadodara-390 005 (Guj)	P.O. Petrochemicals Distt-Vadodara (Guj) Ph: 0265-372681-82
Gujarat Heavy Chemicals Ltd	F-Block, 2nd Floor International Trade Tower Nehru Place New Delhi - 110 019 Ph: 011-6445154 (5 lines)	Village-Sutrapada Distt-Junagarh Near Veraval (Guj) Ph: 02876-22014/5
Hindustan Heavy Chemicals	Globe Buildings, 4th Floor 7E, Lindsay Street Calcutta - 700 087 Ph: 033-2454825	19, Barrackpore Rd. P.O. Balaram Dharma Sopan - 743 121 Distt-24 Parganas(N) West Bengal Ph: 033-5532879
Hindustan Paper Corp	Vishal Bhawan 95, Nehru Place New Delhi - 110 019 Ph: 011-6432891	1. Nagaon Paper Mill P.O. Kagaznagar 782 413, Jagi Road Distt-Morigaon Assam Ph: 03678-2331/227 2. Cochar Paper Mill P.O. Panchgram 788 802 Dist-Hailakandi Assam Ph: 03845-2106
Hukumchand Jute & Industries Ltd	15, India Exchange Place Calcutta - 700 001 Ph: 033-2201578/2207379	P.O. Amlai Paper Mill Distt-Shahdol 484 117 (M.P) Ph: 07652-6855/291

Indian Rayon & Industries Ltd	Industry House 159, Churchgate Reclamation Mumbai - 400 020 Ph: 022-2023946/2023915	Junagadh-Veraval Rd Veraval - 362 266 Gujarat Ph: 02876-20201
Jayshree Chemicals Ltd.	14, Netaji Subhash Road Calcutta - 700 001 Ph: 033-22007332/5998/2793	P.O. Jayshree Dist-Ganjam-761025 Orissa Ph: 06811-8319/29
Kadakia Alkalies & Chemicals	Ramkrishna Chambers, 5th Fl Productivity Road Alkapuri, Baroda - 390 005 Gujarat Ph: 0265-325769/330019	Ankleshwar-Hansat Baridra, P.O. Box-16 Ankleshwar-390 005 Dist-Bharuch (Guj) Ph: 02646-55684
Kanoria Chemicals & Industries Ltd	Park Plaza, 7th Floor 71, Park Street Calcutta - 700 016 Ph: 033-2499472/2499775	PO. Renukoot-231217 Dist-Sonebhadra(U.P) Ph: 05446-52044/55
Modi Alkalies & Chemicals Ltd	18, Community Centre New Friends Colony New Delhi - 110 065 Ph: 011-6838208/6831773	Sp.-460, M.I.A. Alwar -301 030 (Raj) Ph: 0144-81061/65
NRC Limited	Ewart House Homi Modi Street Mumbai - 400 023 Ph: 022-2652490/8	Post-Mohone-421102 Thane Distt. (Kalyan) Maharashtra Ph: 0251-546311-18
Punjab Alkalies & Chemicals Ltd	SCO: 125-127 Sector 17-B, P.O.-152 Chandigarh - 160 017 Ph: 0172-703645/47	Nangal-Una Road Naya-Nangal-140126 Distt-Ropar (Punjab) Ph: 01887-20750/51
Punjab National Fertilizers & Chemicals Ltd	SCO: 119-120, Sector 17-B Chandigarh - 160 017 Ph: 0172-703134, 704118	Naya-Nangal-140126 Distt-Ropar (Ph: 01887-20750/3
Reliance Petro-Chemicals Ltd	Village More Taluka-Chorasia Distt. Surat - 394 510 Gujarat Ph: 0261-96401/11	Village More Taluka-Chorasia Distt. Surat-394 510 Gujarat Ph: 0261-96401/11
Search Chem Industries	4th Floor, Readymoney Terrace 167, Dr. Annie Besant Road Worli, Mumbai - 400 018 Ph: 022-4930681/4930560	750, G.I.D.C. Jhagadia Distt. Bharuch (Guj) Ph: 02645-20161

Siel Foods & Fertiliser Industries	Surya Kiran Building 19, Kasturba Gandhi Marg New Delhi - 110 001 Ph: 011-3319010	15, Shivaji Marg P.O. Box: 6219 New Delhi-110 015 Ph: 011-5100190
Southern Petro-Chemical Industries Corpn	SPIC Centre, 2nd Floor 97, Mount Road Guindy, Madras - 600 032 Ph: 044-235-329/2350337	
Sree Rayalaseema Alkalies & Allied Chemicals Ltd	Gondiparla Kurnool - 518 004 AP Ph: 08518-22206/7/8	Gondiparla Kurnool-518004 (A.P) Ph: 08518-22206/7
Standard Alkalies	Mafatlal Centre, 6th Floor Nariman Point Mumbai - 400 021 Ph: 022-2021823	P.O. Ghansoli Thane-Belapur Road Distt. Thane-400601 Maharashtra Ph: 022-7692052
Tata Chemicals Ltd	Bombay House 24, Homi Mody Street, Fort Mumbai - 400 001 Ph: 022-2049131	Mithapur -361 345 Okhamandal, Guj. Ph: 02892-22207
The Ravancore-Cochin Chemicals Ltd	Post Box No: 4004 Udogmandal P.O Kochi-683 501, Kerala Ph: 0484-551011	Post Box No: 4004 Udyogmandal P.O. Kochi-683501 (Ker) Ph: 0484-551011
Tuticorin Alkali Chemicals & Fertilisers Ltd	East Coast Centre 553, Anna Salai Teynampet, Madras -600 018 Ph: 044-4345276/43349560	Harbour Construction Road, SPIC Nagar Tuticorin-628005(TN) Ph: 0461-52612/13

Annex B Pulp Mills in India

Paper Mill name	Region	Address	Type of material used	Output Tonnes per annum
The Five Mills of the Governmental Hindustan Paper Corporation Ltd Calcutta (only of the 3 largest)				28,000
Cachar Paper Mill	Assam	Panchgram, Dist. Hailakandi	Bamboo and mixed hardwood kraft pulp	100.000
Nogaon Paper Mill	Assam	Kagaj Nagar,. Morigaon	Bamboo and mied hardwood kraft pulp	100.000
Hindustan Newsprint Ltd	Kerala	Newsprint Nagar,. Kottayam	Eucalyptus, bamboo, reed and CTMP pulp	80.000
Mandya National Paper Mills Ltd	Karnataka	Belagula, Mysore	Bagasse, bamboo, reed pulp	18.000
Nagaland Pulp & Paper Co. Ltd	Nagaland	Paper Nagar, Mokakchung	Bamboo, reed pulp	18,000
The 17 Large Private Mills of Pulp for Paper Production (each over 40.000t)				1,142,000
Sirpur Paper Mills Ltd	Andhra Pradesh	Sirpur-Kaghanznagar	Bleached bamboo and hardwood and rag pulp	60,000
The Andhra Pradesh Paper Mills Ltd	Andhra Pradesh	Secunderabad	Bleached bamboo and hardwood pulp	70,000
Shree Rayalaseema Paper Mills Ltd	Andhra Pradesh	Kurnool Mill, Vasantha Nagar, Kurnool, AP	Bleached hardwood, bamboo and straw kraft pulp.	45.000
Bhadrachalam Paperboards Ltd Sarapaka Mill	Andhra Pradesh	Sarapaka Mill Sarapaka, Khamman	Bleached and unbleached hardwood and bamboo pulp	95,000
Tamil Nadu Newsprint & Papers Ltd	Madras, TN	Pulalur Mill, Kagithapuram, Trichy	Bagasse and eucalyptus kraft pulp	90,000
Seshasayee Paper and Board Ltd	Madras, TN	Erode House, Erode TN	Bleached hardwood and bamboo and bagasse kraft pulp	50,000
West Coast Paper Mills Ltd. Bombay	Karnataka	Dandeli Mill Dandeli, U.K	Hardwood and bamboo and bagasse pulp.	70.000
Mysore paper Mills Ltd	Karnataka	Bhadravati Plant Bhadravati Shimoga	Hardwood and bamboo and bagasse pulp	100.000
Ballarpur Industries Ltd, New Delhi	Gujarat	Fort Songandh Plant, Fort Songadh,. Surat,	Bleached and unbleached hardwood and bamboo pulp	80.000

Central Pulp Mills Ltd, New Delhi	Gujarat	Fort Songadh Plant, Fort Songadh, Surat,	Bleached hardwood and bamboo pulp	40.000
Nepa Ltd	Madhya Pradesh	Nepanagar, Madhya Pradesh	Bleached bamboo and bagasse pulp	50.000
Orient Paper & Industries Ltd., Calcutta	Madhya Pradesh	Amlai Mill, Amlai, Dist. Shahdol. MP.	Hardwood and Bamboo kraft pulp	70.000
Ballarpur Industries ltd, New Delhi	Haryana	Shree Gopal Mill, Yamunanagar, Ambala,	Bleached hardwood and bamboo pulp, rag pulp	42,000
Century Pulp & Paper, Bombay	Uttar Pradesh	Ghanshyamdham Mill, Lalkua, Nainital, UP	Soft-and hardwood pulp, bamboo pulp	80.000
Star Paper Mill Ltd, Calcutta	Uttar Pradesh	Saharanpur Mill, Saharanpur, Uttar Pradesh	Bleached bamboo and hardwood and softwood kraft.	40.000
Orient Paper & Industries Ltd, Calcutta	Orissa	Brajrajnagar Mill, Brajrajnagar,. Jharsuguda,	hardwood and bamboo kraft pulp	60.000
J.K. Corporation Ltd, New Delhi (formerly Straw Products).	Orissa	Rayagada Mill, Jaykaypur, Rayagada	Bleached bamboo and hardwood kraft pulp	100.000

The 5 Large Mills for Dissolving Rayon Grade Pulp for Viscose				285,000
Grasim Industries Ltd Birlagram, Nagda, Madhya Pradesh	Kerela	Gwalior Rayons Mavoor,.	Dissolving hardwood and bamboo pulp	72.000
Grasim Industries Ltd. Birlagram, Nagda, Madhya Pradesh.	Karnataka	Harihar Polyfibres, Harihar, Dhawar,	Dissolving hardwood and bamboo pulp	58.000
SIV Industries Ltd. (South India Viscose),	Tamil Nadu	Sirumgai Mill, Sirumgai, Coimbatore,	Rayon grade eucalyptus wood pulp .	60.000
Andhra Pradesh Rayons Ltd, Secunderabad	Andrha Pradesh	Kamalapuram Mill, Kamalapuram , Warangal.	Dissolving hardwood rayon grade pulp	50.000
Travancore Rayons Ltd	Kerala	Rayonpuram	Dissolving hardwood rayon grade pulp, viscose and nutrition grade pulp	45.000

Summary	Total Summary
The 3 large mills of the Governmental Hindustan Paper Corporation, Calcutta	280.000
The 17 large private mills of pulp for paper production	1.142.000
The 5 Mills for dissolving rayon grade pulp for viscose.	285.000
All 25 large mills over 40.000 t annual output	1.700.000
The 90 small mills	less than 40.000
All mills together	2,600.000

ANNEX C OTHER PLASTICS

This appendix examines the following seven plastics:

- 1 Polyolefins: Polyethylene and Polypropylene (PE and PP)
- 2 Polyethylene terephthalate (PET)
- 3 Polystyrene (PS)
- 4 Polyurethane (PUR)
- 5 Polycarbonate (PC)
- 6 Acrylonotrile-Butadiene-Styrene (ABS)

The first three of these can be considered transition materials to replace PVC plastic. The last four PUR, PC, PS and ABS cannot be regarded as substitutes for PVC plastic.

1. Polyethylene and Polypropylene (PE/PP)

The polyolefins, polyethylene (PE) and polypropylene (PP), are polymerised olefines. They are made from the alkenes, ethylene and propylene.

In its various forms, PE is the most common plastic in the world. It dominates the food packaging sector. Building materials made from PE are tough, flexible, water impermeable, and have good chemical resistance. However, they do suffer from low tensile strength and have poor weathering qualities. [176, Australia, 1994] They are used mainly as moisture barriers, damp-courses, pipes and electrical insulation. In the building sector, PP is used in pipe fittings. It is highly resistant to acids, alkalis and other destructive agents. PP produces excellent pipe joint weldings.

The main environmental problems of PE/PP include:

- PE and PP, both involve the cracking of hydrocarbon feed-stocks which generate persistent organic substances, such as polyaromatic hydrocarbons.
- Ethylene and propylene are highly flammable
- Compared to PVC, PE/PP production involves less occupational and environmental impacts. However, PE/PP process workers have reported a range of illnesses from nasal irritation, headaches, skin irritation and nausea, to colorectal cancer and 'meat wrappers asthma';
- PE/PP contain a range of additives - UV and heat stabilisers, anti-oxidants, anti-blocking agents, colorants, blowing agents and fillers. PE and PP do not require plasticisers such as DEHP Flame retardants are used as these plastics are highly flammable. They can be both brominated and chlorinated chemicals, whose content can reach 40%. They are capable of releasing dioxins into the environment.
- Heavy metals, such as lead powders, are used as fillers in PE/PP. Leaching of these additives in landfills results in soil and groundwater contamination.
- Thermal degradation of PE/PP releases many volatile compounds; for PE, 44 organic compounds have been identified. Two of these compounds, formaldehyde and acetaldehyde, are listed as carcinogenic by the Danish Labour Inspection Service.
- During the burning of PE/PP, polycyclic aromatic hydrocarbons are released. If flame retardants are present, highly corrosive acids are formed, but in smaller amounts than PVC.

The above list of the environmental woes of PE/PP demonstrates that even the better petrochemical-based plastics are still very hazardous.

However, in comparison with PVC, PE/PP have:

- Fewer problematic additives.
- Reduced leaching potential in landfills.
- Reduced potential for dioxin formation during burning, due to the absence of chlorine, provided that brominated/chlorinated flame retardants are not used.
- Reduced technical problems and thus costs during recycling.
- A feasible chlorine-free processes for propylene oxide - the building block of PP - already exists.

The end-markets for recycled high density polyethylene are agricultural drainage pipes, animal pens and kerb stops. This is down-cycling. It is not true recycling, where a used PE product is recycled back into the same product.

2. Polyethylene terephthalate (PET)

PET is a thermoplastic polymer made from ethylene glycol and terephthalate. Two types of PET exist, the transparent, amorphous type (A-PET) and a whitish, crystalline type (C-PET).

PET can contain the following additives: UV stabilisers, flame retardants, pigments, anti-oxidants and anti-statics.

Occupational health impacts associated with PET production include worker handling of toxic chemicals such as pigments, catalysts, phthalates, nickel and hexamethylene diamine. This has shown up in increased cancer rates. However, this is true of all plastics which contain toxic additives.

During burning, hydrocarbons, additives and heavy metals are released. In landfills, additives will leach out of PET.

Recycled products can be made with 100% pure recycled PET, without the need for virgin plastic.

However, prevention and re-use is always better than recycling. Even though PET can be truly recycled - rather than 'down-cycled' as with PVC - recycling always entails excessive use of energy to transport the post-consumer waste to a centralised processing facility.

Since PET has no chlorine content, fewer additives than PVC, and provided brominated/chlorinated flame retardants are excluded, it is environmentally a better plastic than PVC.

The following plastics: polystyrene (PS) polyurethane (PUR), polycarbonate (PC) and ABS are considered by Greenpeace to be at least as hazardous as PVC and should not be used as substitute plastics.

Both polyurethane and polycarbonate are made using phosgene. (see Box X Phosgene). However, alternative non-phosgene methods of producing PC are currently being developed.

PS uses known and suspected cancer-causing substances in its production. The chlorinated solvents used to make PS render it unacceptable as an alternative to PVC. ABS or Acrylonitrile-Butadiene-Styrene production also uses a number of environmentally problematic chemicals.

3. Polystyrene (PS)

Polystyrene is made from benzene and ethylene. As a building material, PS is widely used for foamed insulation. It can also be hard, rigid and transparent and brittle, with low heat resistance. Its weathering performance is poor.

Different polymerisation processes result in different PS grades:

- general purpose (crystal) - clear and brittle;
- high impact polystyrene (HIPS) - copolymer added (polybutactine) gives extra strength
- expandable polystyrene bead (EPS) - blowing agent added for insulation/impact resistance

PS is not an acceptable alternative to PVC because the raw materials used in its production include benzene, ethylbenzene, styrene and butadiene. Benzene is an established human carcinogen. Exposure to high concentrations (50-150 ppm) can cause narcotic effects with symptoms of dizziness and light-headedness. Long term exposure can cause blood disorders, like leukaemia or a plastic anaemia.

Styrene is used in the production of both PS and ABS. It can be absorbed through the skin. Short term exposure can cause irritation of the eyes, nose and throat, vomiting and depression. Extreme exposure may cause unconsciousness and death. Long term exposure may effect the nervous system. Styrene is a possible carcinogen and has been implicated in human lymphatic and blood cancers. The International Agency for Research on Cancers, IARC (1987) has recognised styrene as carcinogenic in animals. Butadiene has been identified as carcinogenic by the Danish Labour Inspection Service.

Additives used in PS include UV stabilisers, anti-oxidants, flame retardants, anti-static agents, plasticisers - including DEHP/DEHA and fillers

The occupational and environmental health concerns associated with the production of PS are the air emissions of styrene recorded near plants and in nearby groundwater and surface water. Foam lowing agents used to make expanded PS can comprise ozone-destroying CFCs.

During the burning of PS, some of the following compounds can be released: styrene monomer, ethylbenzene, benzene, acetylene as well as hydrogen chloride and dioxins if brominated or chlorinated flame retardants are present. The Danish Labour Inspection Service has also revealed cancer-causing styrene oxide to be released during burning.

Land-filling low density EPS consumes a lot of space. This has led to U.S. restrictions on EPS, as a food packaging material in states, like Oregon. The problem of PS additives leaching out of landfills is largely unresearched and unknown.

Technically it can be recycled. Recycled polystyrene is can be down-cycled into foam cushioning shapes, cassette casings and rigid sheets. Research is currently trying to convert PS into protein for animal foodstuffs and ultimately, human consumption. The presence of stabilisers, plasticisers and flame retardants in the PS will hopefully hamper these efforts. EPS can potentially be re-compacted back into PS.

Although PS has no chlorine content and far fewer additives than PVC, it is not an acceptable substitute for PVC mainly due to its cancer-causing raw materials.

4. Polyurethane (PUR)

PUR is made from isocyanates and polyols. It is produced by a reaction involving isocyanates, a polyester or polyether resin and a blowing agent. PUR raw materials and intermediate products include phosgene. toluene disocyanate, propylene chlorhydrin, additives, the ozone depleting gases: methylene chloride and CFCs (CFC 11) as well as flame retardants and pigments.

The production of PUR and its intermediate products uses 11% of total world chlorine production. In the building sector PUR is used for insulation, furniture seating, artificial leather, tarpaulins, flexible tubings and carpet underlay.

PUR production materials have been linked to several occupational and health problems, including heart diseases, asthma and reduced sperm quality. Toluene diisocyanate, used to make PUR foam, can cause chemical bronchitis and, in some cases, fatal lung damage. Long term exposure can produce asthma-like symptoms and reduce lung function. TDI is carcinogenic in laboratory animals.

The burning of PUR releases isocyanates, carbon dioxide cyanides, hydrogen cyanide benzene, hydrogen chloride and dioxins. However, dioxins and other halogenated compounds will only be produced if halogenated flame retardants are present.

In landfills, PUR ester foams have been observed to degrade, generating leachates and releasing ozone-destroying CFCs and HCFCs (hydrochlorofluorocarbons).

Briefly, the main environmental and human health problems for PUR stem from its ingredients, which include: isocyanates, CFC blowing agents, halogenated flame retardants and the chlorine requirements of intermediate products.

Due to PURs problematic production processes and additives, the Danish Environmental Protection Agency concluded that: "isocyanates result in considerable disadvantages in the work environment compared with PVC. When using PUR, environmental improvements will be obtained in waste management due to the absence of heavy metals and chlorine. However those advantages are not sufficient to make it a better alternative"

The available evidence indicates that PUR cannot be recommended as an environmentally acceptable alternative to PVC.

5 Polycarbonate

Most commercial polycarbonates are derived from bisphenol-A poly-carbonate. Polycarbonates are polyesters produced in one or two ways. The first uses phosgene and hydrogen chloride; the second uses carbonate ester. Phosgene is an extremely hazardous toxic cloud gas, produced using chlorine gas.

The non-phosgene commercial routes are currently the subject of intensive research. GE Plastics, at their polycarbonate plant in Japan, use a chlorine-free (hence phosgene-free process. Huls America and BASF are planning di-isocyanate units based on a new phosgene-free process. Montsanto chemists are researching methods to make urethanes and isocyanates from primary amines and carbon dioxide, without the use of phosgene.

Toughness, transparency, resistance to burning and maintenance of useful engineering properties over a temperature range from - 200 to +140 degrees C are the main features of polycarbonates. In the building industry, they are used for break resident windows, canopies and combinational electrical insulation.

Polycarbonate made using the non-phosgene process may seem an acceptable alternative to PVC for durable building products. It seems that additives are not used in the production of PC.

However the solvents used to prepare the polymer are problematic. Most polymer is produced and characterised in solution. The most common solvent is methylene chloride, a carcinogen. Other solvents may be include chloroform, 1,2,dichloroethylene, tetrachloroethane and chlorobenzene.

6 ABS

Acrylonitrile-butadiene-styrene resins are thermoplastics that have a wide variety of composition, preparation conditions and properties. Compositions generally run at about 20-30% acrylonitrile, 20-30% butadiene and 40-60% styrene.

The resins are typically tough and rigid easy to extrude and mould with good thermal and abrasion resistance. They can be alloyed and blended with other resins, especially PVC or polycarbonate and can be shaped by almost any plastic fabrication process: injection moulding, extrusion or thermoforming.

In building products they are used for pipes, ducts and structural foam. The structural foams are made using a blowing agent or mixing a gas into the hot melt, then injecting it into a mould where the gas expands to form a cellular product. The foams are used for large parts in which light weight and rigidity are desired.

ABS uses a number of environmentally problematic chemicals. These include acrylonitrile and strene. The problems of strene have already been discussed. Acrylonitrile is readily absorbed by humans both by inhalation and directly through the skin. Both the liquid and its vapour are highly toxic showing many of the characteristics of the cyanide ion. The vapour is heavier than air and may cause sever eye irritation, headache and nausea. Acrylonitrile is classified as a probable human carcinogen.

Additives used include antioxidants and light stabilisers. Antioxidants are needed since ABS undergoes auto-oxidation. Photo-oxidation are controlled by adding light stabilisers, pigments, protective coatings and film.

Flame retardants include antimony-based and halogen-based compounds. However, a new flame retardant using polymer-bound bromine has been developed to avoid additive bloom and reduce toxicity. Paints may also be used together with lamination techniques where ABS is laminated with another plastic, often PVC or PC.

Worldwide total production of ABS polymers in 1989 is estimated at 3,438kt. The biggest manufacturers are GE plastics ChiMei Industrial and Monsanto.

In view of its varied composition ABS is extremely difficult to recycle. Furthermore, its many toxic constituents make it an unacceptable alternative to PVC.

Box X Phosgene

Phosgene is produced by mixing carbon monoxide and chlorine gas over activated carbon. It is used to make isocyanates which are intermediaries in the production of plastics and pesticides. The production of polyurethane alone, consumes over 85% of the world's phosgene production. Another significant use of phosgene is in polycarbonate production.

Phosgene is a particularly hazardous gas which forms vapour clouds if leaked into the atmosphere. These gas clouds, which can travel very fast, asphyxiate humans and destroy plants in their paths. Vapour clouds can ignite to form moving fire balls. Many of the major chemical accidents that have occurred in the past decade have involved the release of toxic cloud gases. Included in this list is the worst industrial accident in history, the methyl isocyanate explosion at Bhopal, India, which led to over 3,500 deaths and many more injuries.

The risks involved in the production, transport and storage of these gases are so grave, and the technologies for limiting damage in the case of accidents so limited, that phosgene production will ultimately have to be phased out. Already safer substitutes are being introduced.

GE Plastics, at their polycarbonate plant in Japan, use a chlorine-free (hence phosgene-free) process. Huls America and BASF are planning di-isocyante units based on a new phosgene-free process. Montsanto chemists are researching methods to make urethanes and isocyanates from primary amines and carbon dioxide, without the use of phosgene.

A 1994 German Prognos report found feasible chlorine-free processes already existed for phosgene, propylene oxide and epoxy resin manufacture. These three intermediates account for over 50% of chlorine use in Germany.

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